DIMENSIONS NBS

The magazine of
the National Bureau
of Standards,
U.S. Department
of Commerce

March 1977

LOOKING THROUGH LEAD. See page 22.

COMMENT

FIRE RESEARCH

The National Bureau of Standards' Center for Fire Research has but one purpose, assigned to us by law: to provide the technical basis for cutting fire losses in this country by 50% within a generation.

Our efforts to meet that mandate are touched on twice in this issue of DIMENSIONS/NBS. In his State of the Bureau address, Acting Director Ernest Ambler briefly explains the Center's planning efforts in response to the Congressional mandate and the resulting strategy for research. Writer Fred McGehan brings us up to date on one aspect of this strategy, namely, the proper use of smoke detectors.

We in the Fire Center base our plans and practices on a consensus, within the fire community, of what constitutes a proper strategy of fire prevention and control. First, we try to prevent fire from starting to the extent that technology, cost limitations, and human comfort will allow. The Center's work on controlling, through federal standards, the flammability of carpets, rugs, mattresses, and children's sleepwear has been focused primarily on ease of ignition. We are now awaiting a decision by the Consumer Product Safety Commission on our proposed standard on the cigarette ignition of upholstered furniture.

We know that we won't be able to prevent all ignitions, that a sizable number will occur. Therefore, the second part of our strategy is to manage the impact of a fire. We approach this by managing the fire itself and by managing the people exposed to the fire.

Warning potential victims by means of smoke detectors is a part of managing the exposed. But to be effective, smoke detectors must be a part of a larger effort by the family to be aware of and sensitive to fire safety problems. As McGehan points out, the occupants of a home must have an escape route and enough time and experience (in drills or, at least, in discussion sessions ahead of the event) so that they may reach a safe place under very trying conditions.

The fire itself can be managed if designers and builders have done their homework. The Center proposes voluntary standards, code changes, and design practices on the rate of burning of interior finishing materials and of furnishings, and has for many years conducted research on the resistance to fire of structural elements of buildings—the fire endurance tests. We are studying the nature and effects of combustion products to determine whether standards are required to control the use of some materials because of unusual toxic effects. We have substantial efforts under way on the chemistry and physics of fire to provide the scientific basis for the next generation of codes and standards.

Some of our work is spectacular. Full-scale room fire experiments at Building 205 are conducted to validate theoretical predictions and to develop correlations (or lack thereof) with bench-scale test methods. NBS staff will recall the large tests run on bus and subway interiors here in 1975 and 1976. At the NBS Annex (the former NIKE missile site down the road) we conduct full scale tests on detectors and sprinklers in simulated hospital rooms and corridors. And, finally, we have a number of specialists who assemble newly won information and translate it into new concepts for the building community.

All of this is done under the conceptual umbrella of the Center's long-range research plan. We believe that our programs are aimed at the right targets and that we will be successful in helping to achieve the national goal of reduction of fire losses.

John W Lyons

John Lyons
Director, Center for Fire Research
Institute for Applied Technology

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UPDATE

Evaluating Incentives for SOLAR Heating Systems

NBS Study Looks at the Question: How much is Enough?

by Madeleine Jacobs

WITH the public's attention captured by the bright promise of solar energy, many people have been thinking of ways to encourage the adoption of solar heating systems in homes and commercial buildings. One obvious way is to provide some kind of financial incentive to the builder or owner. In fact, twelve states already have passed bills that provide various kinds of direct financial incentives for purchasing solar energy systems. These include property tax exemptions, tax credits, and sales tax exemptions. Many other states will be considering similar legislation in the next few months.

Despite the legislative activity, no one really knows for sure whether or not these incentives will be effective. Economist Rosalie Ruegg at the National Bureau of Standards in Gaithersburg, Maryland, recently took a hard and detailed look at the questions relating to financial incentives for solar heatings systems.* The information and her findings, which contain a few surprises, are intended to provide state and federal legislators and those in the financial community with some guidelines on formulating effective incentive programs. The approach, however, is widely applicable to the evaluation of solar energy systems in general.

"One of the key findings in the study," Ruegg says, "is that incentive policies now being enacted in some states may not be sufficient to encourage people to adopt solar energy systems. In other words, even with an incentive, the homeowner in many cases will be better off economically with conventional power. In some other cases, incentives may not even be needed." This appears to be true, she says, in some climates where solar is already competitive with high-priced conventional energy.

Ruegg's study is an outgrowth of her research in the NBS Building Economics Section of the Center for Building Technology. Earlier, she had published guidelines* that could be used to compare and evaluate the economic costs and benefits of solar versus conventional heating and cooling systems. The latest research was spurred by a request of the National Conference of State Legislators which asked her to examine the incentive question in the interest of promoting more effective programs.

Ruegg extended her economic evaluation model to take into account the effects of seven different incentives. "The seven were selected because my review of current legislation showed that these were the principal types under consideration at the state and federal levels," Ruegg explains. The seven are direct grants, income tax credits, property tax exemption, sales tax exemption, income tax deduction for depreciation, loan interest subsidy, and a tax on conventional energy (see box for definitions).

Her method of evaluation consists of a life-cycle model for determining the annual net savings or losses to the owner of a solar heating system used in a building for the assumed lifetime of the system. The calculation of annual net savings or losses takes into account the costs of purchase, installation, maintenance, repair, insurance, and interest; as well as the cost savings from reduced consumption of conventional energy; the combined cost effects of normal property taxes, sales taxes, and income tax deductions; and the modifying cost effects of the seven incentive policies.

Ruegg points out that the evaluation considers only economic factors that would directly affect the owner. "I did not try to take into account other potential benefits or costs such as reduced environmental pollution, balance of payments effects, or the value of conserving fossil fuels for future generations," Ruegg notes. "This is because the private decision-maker who is free of government control probably would not take into account all the external social costs and benefits that would result from solar applications." On the other hand, she points out that these factors in reality provide the economic rationale for publicly provided incentives to encourage private use of solar energy systems.

"One of the key findings in the study is that incentive policies now being enacted in some states may not be sufficient to encourage people to adopt solar energy systems."

To make the evaluation model more applicable and easier to use, Ruegg wrote a computer program that allows the user to specify the values of important factors in the analysis, such as the cost of conventional fuel. "By applying the cost model to

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Jacobs is a writer and public information specialist in the NBS Office of Information Activities.

* *Evaluating Incentives for Solar Energy Systems,* (revised edition in press; will be available from the Superintendent of Documents).

* *Solar Heating and Cooling in Buildings: Methods of Economic Evaluation,* National Technical Information Services, Springfield, VA 22151 (COM-75-11070), $3.75.

measure owner costs, both with and without each of the incentives, it is possible to answer three major questions," according to Ruegg. "First, is an incentive needed to make solar energy systems cost effective under the specified conditions? Second, how much change is required to make them cost effective? Third, which particular incentive or combination of incentives will achieve a given level of profitability for the owner?"

In her report, Ruegg applied the evaluation method in six case studies. Four deal with typical houses in climatic regions like that of Madison, Wisconsin, and Albuquerque, New Mexico. The other two case studies are for a commercial building in a climatic region like that of Madison. The model can be used for any building type or climate in the United States. In addition to illustrating the usefulness of the evaluation method and computer program, the case studies provide a basis for analyzing the impact of a variety of specific incentive programs under realistic conditions.

In each of the case studies, the cost effectiveness of solar energy systems was determined under eight conditions. The first condition was without taxes or consideration of any incentives. The second condition was with existing taxes but without incentives. The remaining six conditions were with existing taxes and one or more of the following incentives: a grant or tax credit of $1000 (considered to have the same impact in this study), an exemption of an assumed 3 percent property tax; a five year depreciation tax write-off of the investment cost of the solar energy system; an exemption of an assumed 4 percent sales tax; an interest subsidy on the mortgage loan of two percent; and a special tax of 20 percent on conventional fuel.

For each of these cases, she considered the cost impact with energy at two prices. The lower price, $0.45 per 100,000 Btu (105 megajoules) of heat output (a therm), corresponds to fuel prices of $0.38 per gallon of fuel oil with a furnace efficiency of 60 percent, $0.015 per kWh of electricity with 100 percent system efficiency, and $0.27 per therm of natural gas with a furnace efficiency of 60 percent. The higher price, $0.90 per therm, corresponds to $0.76 per gallon of fuel oil, $0.03 per kWh of electricity, and $0.54 per therm of natural gas with the same furnace efficiencies as the lower prices. The lower prices are typical of gas and oil costs in many parts of the country today, while the higher price is more typical of electrical costs. Other key assumptions used in the model are listed in Table 1.

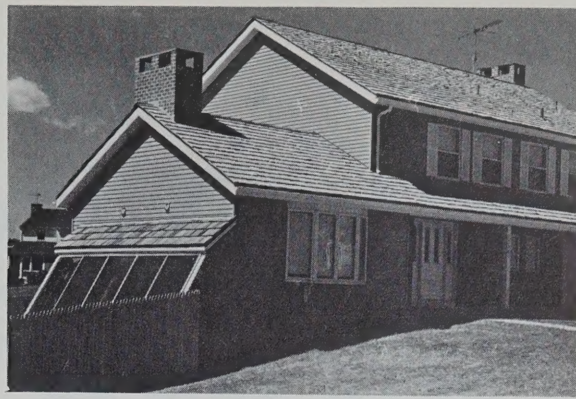
**Table 1—
KEY ASSUMPTIONS USED IN MODEL FOR EVALUATING DIFFERENT INCENTIVE POLICIES IN CASE STUDIES**

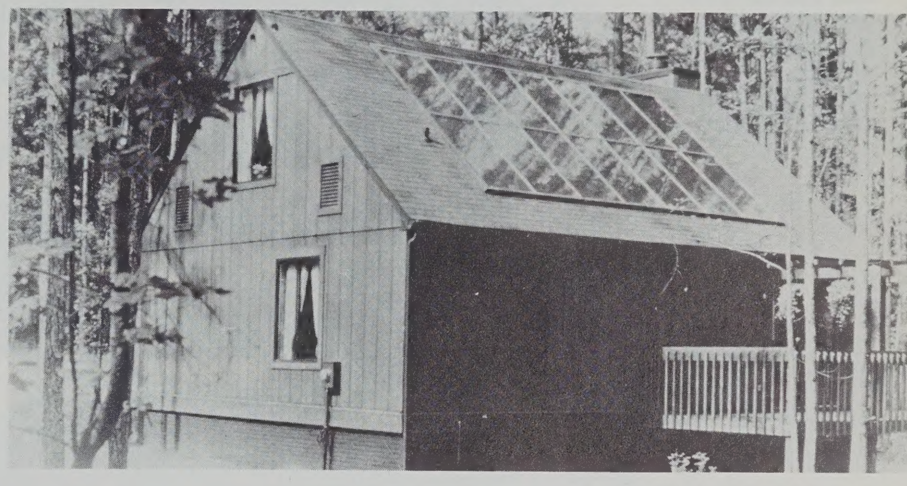
BUILDING SIZE	1500 ft^2 (139 m^2)
HEAT LOSS FACTOR	10 Btu/(ft^2 • °F • day) = 204 kJ (m^2 • °C • day)
"STANDARD" LIQUID SOLAR HEATING SYSTEM	
COLLECTOR AREA	500 ft^2 (46 m^2)
COLLECTOR PRICE @ $10.50/$ft^2$ ($113/$m^2$)	$5250
NON-COLLECTOR SOLAR COMPONENTS	$1700
ASSUMED LIFETIME OF SOLAR AND CONVENTIONAL ENERGY SYSTEMS	25 Years
LOAN INTEREST RATES	9½% Market Rate, Residential & Commercial 4½% Real Rate, Residential & Commercial
DISCOUNT RATES	3% Real Rate, Residential 10% Real Rate, Commercial
"TYPICAL" TAX RATES	Personal income tax, composite state & federal rate 32% Corporate income tax, composite state & federal rate 51% Property tax 3% Sales tax 4%
ENERGY COST (1 therm = 105 megajoules)	$.45/therm output ($0.15/kWh elect., $.38/gal. oil, $.27 therm gas) $.90/therm output ($.03/kWh elec., $.76/gal. oil, $.54 therm gas)
FUEL PRICE ESCALATION RATE	10% nominal rate, 5% real rate
HEATING LOADS	Albuquerque, New Mexico .... 65 $\times 10^6$ Btu (69 GJ). Madison, Wisconsin .... 118 $\times 10^6$ Btu (125 GJ)
PROPORTION OF HEATING LOAD SUPPLIED BY SOLAR ENERGY SYSTEM	Albuquerque, New Mexico .... 75% (49 $\times 10^6$ Btu) (52 GJ) Madison, Wisconsin .... 47% (55 $\times 10^6$ Btu) (58 GJ)

Table 2 summarizes the results of the six case studies. Looking at the residential case for Madison, Ruegg points out that none of the particular incentives examined would alone be large enough to make the assumed solar heating system cost effective with the conventional energy at $0.45 per therm. However, by combining several of the more effective incentives, it is possible to develop a strategy that would provide a strong profit incentive to homeowners to invest in solar. For example, by combining the property tax exemption and the five year depreciation tax write-off, the solar heating system would save the owner $130 a year over the lifetime of the system. These are net savings; that is, the cost of the system has already been accounted for in the calculation.

"Of course, if the cost of energy were doubled to $0.90 per therm, all of the incentives would, in this case example, make the system highly attractive," Ruegg says. "Even without an incentive, the homeowner would get a substantial net savings. So in this case, the special incentives should not really be necessary to encourage homeowners because the solar energy systems are already cost-effective." Instead, she suggests that a public information campaign would be better—to alert consumers, builders, lenders, and other members of the building community to the potential savings to be realized from heating with solar power.

An interesting finding in the analysis was the comparison of residential cases for Madison and Albuquerque. "Most people would probably assume that the Albuquerque case would be more profitable than Madison because of the sunnier climate in New Mexico," Ruegg says. "But for the same sized system, it turned out to be slightly less favorable from a cost standpoint. This apparent inconsistency reflects the fact that the solar energy system assumed for purpose of the case studies is probably sized more appropriately to fit Madison than Albuquerque, and that the difference in the performance of the solar energy systems—75 percent of the heating load in New Mexico versus 47 percent in Wisconsin—was more than compensated for by the larger heating load in Madison. The net effect was more Btu's supplied by the solar energy system in the Madison case than in the Albuquerque case. Given the size and efficiency of the systems compared, it appears that a larger incentive would be required to promote solar energy systems in Albuquerque than in Madison." This finding points up the importance of encouraging the use of appropriately sized systems in order to reduce the need for incentives.





Solar energy systems are becoming more popular for traditional houses like this one in Reading, PA (top) as well as for vacation homes like the one below in Peachtree, GA.

The case study for the commercial building also provided a few surprises. The result showed that the solar energy system was substantially less profitable for a commercial building than its counterpart residential application. "The study suggested that for equal size buildings and heating loads, a larger incentive appears to be required to make solar energy cost effective for a business than for a homeowner," according to Ruegg. This is because current tax laws allow commercial owners to deduct conventional fuel costs as a business expense and this deduction is not offset by normal depreciation allowances. As an alternative to the seven incentives considered, Ruegg suggests that "policy makers might wish to consider measures to remove the existing bias in current income tax laws against commercial use of solar energy systems. This could be done, for example, either by eliminating the deduction of current conventional fuel costs as a business expense, or by allowing a counterpart tax deduction for the value of the conventional energy saved by using solar energy." The bias also could be reduced by increasing the depreciation deduction. She believes that further research is needed to determine the comparative impact of incentives for businesses and homeowners, so that effective incentive programs could be designed for both sectors. Such programs would provide the largest return per dollar of incentive provided, she explains.

What does all this mean for new and existing incentive programs? Says Ruegg, "I think it shows that in some states, the incentive policies now being enacted will not be sufficient to encourage the

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Table 2— ANNUAL SAVINGS TO THE OWNER OF A SOLAR-EQUIPPED BUILDING WITH & WITHOUT INCENTIVES: CASE STUDIES[a]

<table>
<tr><th></th><th></th><th></th><th colspan="8">ANNUAL NET SAVINGS IN DOLLARS</th></tr>
<tr><th></th><th></th><th></th><th>(1)</th><th>(2)</th><th>(3)</th><th>(4)</th><th>(5)</th><th>(6)</th><th>(7)</th><th>(8)</th></tr>
<tr><th>BUILDING TYPE</th><th>SELECTED LOCATIONS</th><th>FUEL COST/ THERM</th><th>BEFORE TAXES & INCEN- TIVES</th><th>WITH EX- ISTING TAXES</th><th>GRANT OR TAX CREDIT $1000</th><th>PROP- ERTY TAX EXEMP- TION</th><th>5 YR. DEPRECI- ATION ALLOW- ANCE</th><th>SALES TAX EXEMP- TION</th><th>INTEREST SUBSIDY 2%</th><th>FUEL TAX 20%</th></tr>
<tr><td rowspan="6">RESIDENTIAL</td><td rowspan="2">Albuquerque, NM</td><td>$.45</td><td>—110</td><td>—190</td><td>—110</td><td>—50</td><td>—80</td><td>—180</td><td>—160</td><td>—140</td></tr>
<tr><td>$.90</td><td>300</td><td>230</td><td>310</td><td>370</td><td>350</td><td>240</td><td>260</td><td>340</td></tr>
<tr><td rowspan="4">Madison, WS</td><td>$.45</td><td>—60</td><td>—140</td><td>—60</td><td>10</td><td>—20</td><td>—130</td><td>—100</td><td>—70</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">130[b]</td><td></td><td></td><td></td></tr>
<tr><td>$.90</td><td>410</td><td>340</td><td>420</td><td>480</td><td>460</td><td>350</td><td>370</td><td>470</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">600[b]</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">COMMERCIAL</td><td rowspan="4">Madison, WS</td><td>$.45</td><td>—220</td><td>—350</td><td>—300</td><td>—250</td><td>—190</td><td>—330</td><td>—300</td><td>—310</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">—90[b]</td><td></td><td></td><td></td></tr>
<tr><td>$.90</td><td>180</td><td>—150</td><td>—70</td><td>—40</td><td>10</td><td>—130</td><td>—100</td><td>—70</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">110[b]</td><td></td><td></td><td></td></tr>
</table>

[a] Note that this compilation of annual savings is based on a specific set of assumptions regarding such variables as cost and performance of the system, the heating load of the building, the future escalation of energy prices, and discount rates and tax rates; a different set of assumptions would produce different results.

[b] The annual savings or losses based on a combination of the two incentives bracketed.

"Given the size and efficiency of the systems compared, it appears that a larger incentive would be required to promote solar energy systems in Albuquerque than in Madison, Wisconsin."

adoption of solar energy systems. More specifically, the results of the case studies imply that the impact of incentive programs will vary considerably depending on the climate, the cost of conventional energy, and the type of building. The current practice of some states to duplicate the incentive programs of other states may result in inappropriate or ineffective legislation."

The case studies also dramatize the importance of considering tax effects in any cost evaluation of solar energy. In every case, Ruegg points out, the after-tax net savings or losses were substantially different from the before-tax net savings or losses.

Perhaps one of the most important conclusions of the study is that in designing an economically effective incentive policy, it is vitally important to carry out a careful assessment of the system costs to owners with and without alternative incentive policies. The NBS study has been distributed to state legislators through the National Conference of State Legislators and has also been made available to federal legislators. It should be extremely useful in helping policy makers design more effective programs in the future. And, although the model was intended to analyze an individual owner's cost for a particular climate region, it can be extended to the consideration of incentive policies on both a regional and national scale. The basic model is also adaptable to the analysis of energy conservation investments other than solar energy systems. □

A short glossary of economic terms

Direct grant:
A cash award to the purchaser of solar energy system.

Income tax credit:
Reduction of person's income tax liability by a specified amount. An income tax credit is essentially the same as a direct grant, as long as the recipient receives any excess of the tax credit over the amount of his or her income tax liability. Therefore, the direct grant and income tax credit are considered to be identical for purpose of the life-cycle cost evaluation in the report.

Income tax deduction for depreciation:
Allows an income tax deduction for depreciation on the capital costs of solar energy systems. The deduction for depreciation can be made to provide incentive in several ways. One way is to expand the current eligibility for capital depreciation deductions for businesses to include homeowners. Another approach is to increase the value of the depreciation, either by shortening the length of time over which the depreciation is written off against yearly tax liability or by otherwise allowing a more liberal depreciation method.

Loan interest subsidy:
A subsidy from the government to reduce the interest rate charged on loans to purchase solar energy systems.

Clearing The Air on Smoke Detectors

by Frederick P. McGehan

SMOKE detectors for the home are a relatively new phenomenon in the American marketplace. Advances in design and technology—plus marketing interest by major business firms—have reduced the price and increased the reliability of such detectors as early fire-warning devices. In 1972 only 50,000 smoke detectors were sold for residential use. Last year sales reached 8 million, aided by an extensive advertising campaign at Christmas time.

The National Bureau of Standards has been performing research on detectors for the last five years. Most recently, this work has involved tests under simulated fire conditions in two residences. One structure was a two-story brick home with a basement; the other was a one-story brick home with a basement. Researchers set smoldering and flaming fires in various rooms, using upholstered furniture and mattresses as fire sources.

The results indicated that one detector may be inadequate to provide early warning in a multi-level house, particularly when the residence is equipped with air conditioning. When an air conditioning system was in operation during the fire tests, it was difficult for smoke originating on one level to pass through moving cold air to rise to a second level.

Therefore, for best warning, NBS researchers recommend one smoke detector on each level. In addition, homeowners may wish to install a heat detector in the attic—or other closed-off spaces—where heat buildup would be rapid.

The Bureau tests also showed that fires originating in bedrooms behind closed doors developed untenable conditions before a detector in the hallway outside the door issued a warning. Therefore, NBS suggests that an additional smoke detector be installed in the bedroom if persons sleeping behind closed doors are incapacitated, are smokers, or have heat-producing appliances or other ignition sources in the room.

Except in special cases (such as closed-off areas as noted earlier), NBS does not recommend the use of heat detectors alone for residential use. In the field tests, heat detectors either failed to respond to a majority of fires or, when they did, took much longer than smoke detectors to sound the alarm.

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McGehan is a writer and public information specialist in the NBS Office of Information Activities.

As more and more homeowners and apartment dwellers consider buying detectors to protect themselves and their families, consumers are seeking information on which to base their purchase decisions. NBS is aiding the consumer by its research reports and consumer-oriented publications.

In January NBS issued an illustrated pamphlet titled "Smoke Detectors . . . What They Are and How They Work." The following is reprinted from that brochure. Single copies are free of charge by writing to "Detectors," Consumer Information Center, Pueblo, Colo. 81009. □

SMOKE DETECTORS
What they are and how they work

The statistics on the loss of life and property due to fire are grim. However, there is an inexpensive and dependable way to protect your home, yourself, and your family—smoke detectors. They provide a reliable early warning system in the event of fire.

How do smoke detectors work?

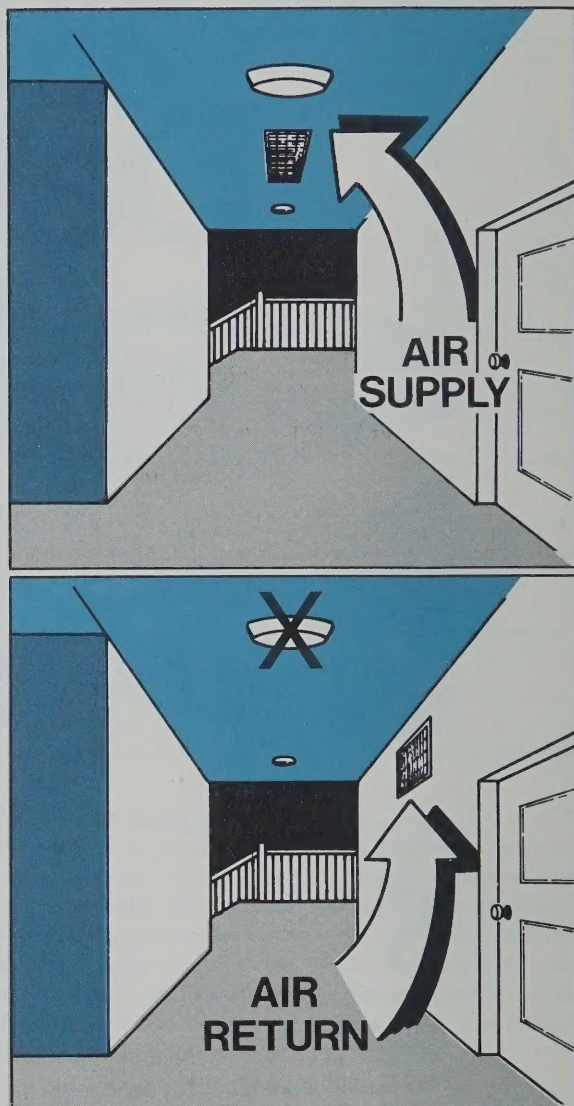
Smoke detectors work by sensing the rising smoke from a fire and sounding an alarm. They can detect smoke far from the origin of the fire. Smoke detectors are most valuable at night—alerting family members to the presence of fire when they are asleep.

There are presently two types of smoke detectors on the market: the photoelectric smoke detector and the ionization chamber smoke detector. The photoelectric smoke detector uses a photoelectric cell and a beam of light. When smoke enters the detector, light from the beam is reflected from smoke particles into a photocell, and the alarm is triggered.

The ionization chamber smoke detector contains a small radiation source that produces electrically charged air molecules called ions. The presence of these ions allows a small electric current to flow in the chamber. When smoke particles enter the chamber they attach themselves to these ions, reducing the flow of electric current. The change in the current sets off the alarm.

Is the radioactive material in an ionization chamber detector a hazard?

No. Before smoke detectors containing radioactive materials are placed on the market, the U.S. Nuclear Regulatory Commission (NRC) performs a radiation safety analysis to make sure that the detectors meet safety requirements.



Location of detectors in relation to air supply and air return registers.

Which detector is better, the ionization chamber smoke detector or the photoelectric smoke detector?

Both types of detectors are equally effective in the home. If properly installed, they can provide adequate warning for the family. Some differences exist between the two when they operate close to the origin of the fire. Ionization detectors will respond more quickly to flaming fires. Photoelectric detectors will generally respond faster to smoldering fires. These differences, however, are not critical. The detector you buy should be approved by a major testing laboratory such as Underwriters' Laboratories, Inc. (UL).

Where is the best place to install my detector?

Because smoke rises, the best place to install a detector is on the ceiling or high on an inside wall just below the ceiling. However, if the ceiling is below an uninsulated attic or in a mobile home, the detector should be placed on the wall 15-30 cm (6-12 in) below the ceiling. In a multi-level air-conditioned home, a detector is needed on each level. On the first floor, the detector should be placed on the ceiling at the base of the stairwell.

Sleeping Areas. Detectors should be installed close enough to the bedrooms so that the alarm can be heard if the doors are closed. Do not install a smoke detector within 90 cm (3 ft) of an air supply register that might blow the smoke away from the detector. A detector should not be installed between the air return to the furnace and the sleeping area as the smoke will be recirculated and diluted resulting in a delayed alarm (see diagrams at right). If you usually sleep with your doors closed, you might consider installing an additional detector inside the bedroom. If a fire starts in the bedroom, the detector inside that room will respond faster than the one in the hallway.

Basement. The detector should be located on the basement ceiling at the bottom of the stairway for the best protection.

If I have a detector in the basement will I be able to hear it in the bedroom?

If you are sleeping, it may be difficult to hear a detector located away from the bedroom area. If you are installing more than one detector, consider purchasing units that can be interconnected. That way, when one unit detects smoke, all detectors will sound an alarm.

How are the detectors connected?

Smoke detectors can be connected two ways: by pulling wires through the walls or by a wireless system. Pulling the wires through the walls is a more permanent method and may require the services of an electrician. The wireless system operates on the same principle as home wireless intercoms. Either procedure is effective.

How are smoke detectors powered and installed?

Detectors are powered two ways: by batteries or by household electric current. Battery-operated detectors are the easiest to install. They require no outlets or connections to household wiring. However, the batteries must be replaced approximately once a year to keep the detector operating properly. The cost of replacement batteries is between $2 and $10.

All UL (Underwriters' Laboratories, Inc.) approved battery-operated smoke detectors are required to sound a trouble signal when the battery needs to be replaced. This 'chrip" signal usually lasts 7 days. If you are away from home for an extended period of time, it is advisable when you return to check your detector, according to manufacturer's instructions, to make sure the battery has not lost power.

Smoke detectors that operate on household current can be powered two ways. The detector, equipped with a 240-270 cm (8-9 ft) electrical cord, can be plugged into an existing wall outlet. A detector powered this way should not be operated with an on-off switch, as it may be accidentally turned off. It can also be wired permanently into your home's electrical system. This procedure requires an electrician, and the cost is usually between $25 and $50.

Will a fire disable a detector that is wired directly to the household electrical power?

A fire in the home electrical circuit that would interrupt power to a smoke detector is a remote possibility. If an appliance, such as a TV set in the living room, starts the fire, a smoke detector located outside the bedroom area should sound an alarm before the fire reaches the electrical wiring. This is particularly true if the TV set and smoke detector are on different circuits.

How do I get the best service from my detector?

Dirt, extreme changes in temperature, and cooking exhaust smoke can cause a false alarm or a malfunction of a smoke detector. To prevent false alarms, locate the detector away from air vents, air conditioners, and fans. Keep the grillwork of the detector dirt-free by dusting or vacuuming. Check and replace batteries periodically. Test detectors every 30 days by using the test button, if provided, or by blowing smoke into the unit.

What do I do if the alarm goes off?

The best fire detection equipment can only tell you that there is a fire. All fire alarms should be used with a family escape plan. A smoke detector in working condition will usually give you at least 3 minutes to evacuate the house. Fire drills should be held so that all family members know what to do. Each person should be aware of all escape routes in the home, including bedroom windows. Do not try to fight the fire yourself. Choose a meeting place outside so you'll know everyone in the house has escaped. Don't stop to call the fire department from your home—use a neighbor's phone.

A Legacy Built of ADOBE:

Preserve with CARE!

by Diedra Van Duzee

THE Tower of Babel was made of adobe—according to one theory at least. In any case, adobe*, which consists of clay soils with varying amounts of coarse material, has an ancient and venerable history. Its use can be traced from Neolithic times to the present. Under favorable conditions, adobe structures can be extremely durable. The Ziggurat** of Agar Quf is still standing after over 2,000 years, as are buildings in China and Peru. However, unfavorable conditions such as rain can accelerate the deterioration of a home made of this sun-dried material, or ravage the face of a valuable landmark.

Although we have nothing as ancient as the Ziggurat, Americans do have a heritage in adobe. Indians and missionaries in the desert areas made extensive use of this material. Their legacy is significant both in terms of history and of archeology. And each year thousands enjoy this heritage by visiting sites like Casa Grande in southern Arizona, a large structure in a walled village built by a stone-age people between 1300 and 1450 A.D.

The National Park Service, state governments, and private organizations are trying to preserve these sites, and the National Bureau of Standards is contributing to the effort. The Park Service has asked the Bureau for help in advancing preservation technology and providing standards for preservation techniques. NBS has the sophisticated research facilities that are necessary for a study on the various facets of adobe preservation. The success of preservation depends, of course, on protecting the historic structures from natural hazards, especially their age-old enemy, water.

"There have been many separate attempts to preserve the historic adobe buildings, but they have often destroyed the original appearance of the constructions or accelerated their deterioration," says George Cattanach, Jr., of the Park Service. "We were treating the symptoms, not the underlying causes. Once we have a better understanding of materials and structures, we can find specific techniques to preserve the adobe. The Bureau is helping us understand the adobe and the basic mechanisms of decay."

Despite the long history of adobe use, the technology of preserving it still needs further development, says Dr. James Clifton of the Center for Building Technology, head of the NBS project on preservation technology which began in June 1976.

Researchers are evaluating preservation materials and methods, characterizing the microstructure and important chemical and mineralogical properties of clay soils that compose adobe, and evaluating non-destructive testing methods to measure the amount of moisture in the structures. They are standardizing test methods, equipment, and methods of reporting the data so the results from different laboratories can be compared directly. Dr. Clifton is also monitoring and coordinating research on adobe preservation carried out by other institutions, such as the University of Notre Dame and Arizona State University.

"The long-term success of preserving adobe seems to depend on protecting it from damage by water," points out Clifton, who recently completed a critical review of the literature on the composition,

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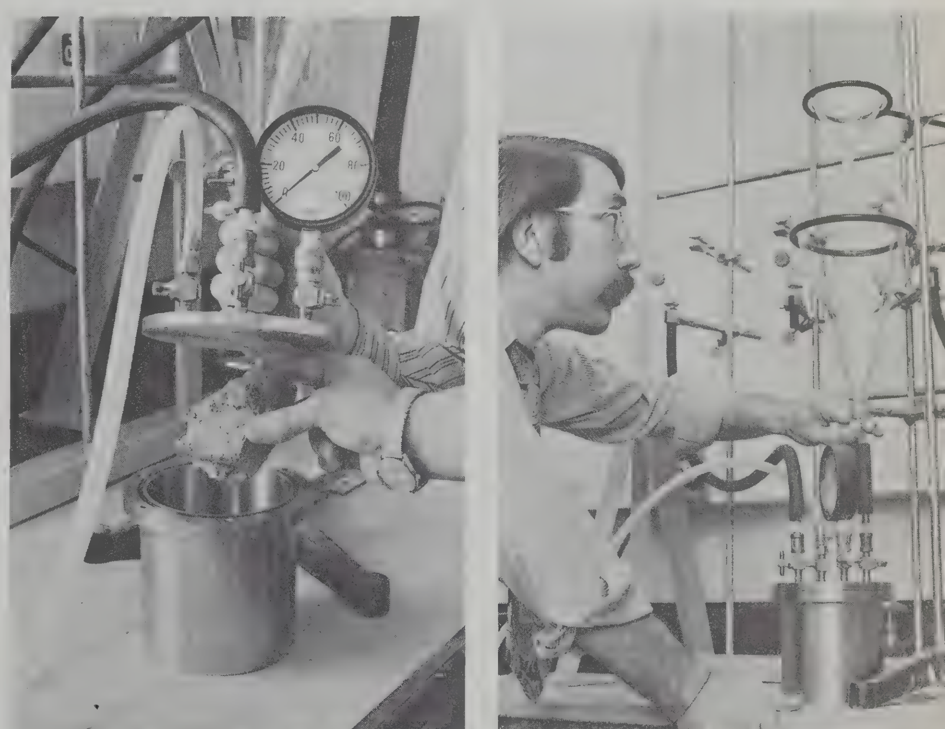
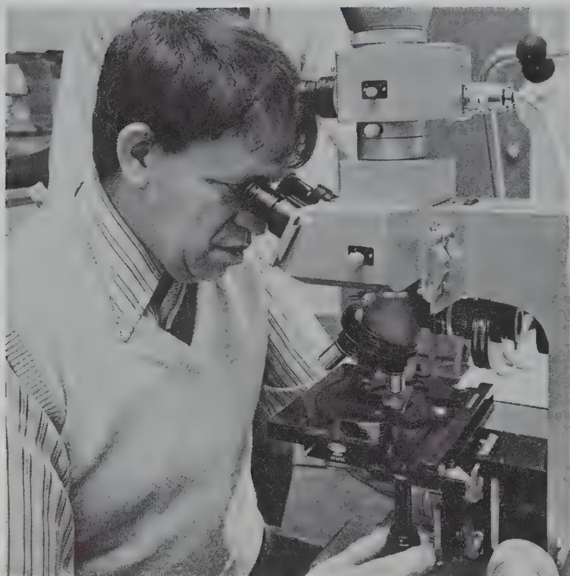


Dr. Paul Brown prepares an adobe specimen for microscopic examination. Specimens are impregnated with methyl methacrylate.

Van Duzee is a staff writer for DIMENSIONS.

*Adobe is defined as any type of clay soil which, when mixed with water to a plaster consistency, can be made into part of a structure.

**A Ziggurat is a pyramidal, stepped temple tower built in major cities of Mesopotamia from 2200 to 500 B.C.



Dr. James Clifton, research chemist, examines an adobe specimen.

physical properties, and durability of adobe and methods to preserve adobe structures.* He found no evidence of satisfactory long-term performance by any of the waterproofing materials that have been used.

The literature review revealed that adobe walls swell when damp and shrink when dried. This alternating expansion and contraction weakens and cracks them. Over a period of years, these cracks widen and can cause the collapse of the structure. Furthermore, water in the walls is subject to freezing and thawing, which can cause great damage.

Rain and ground water erode adobe walls. The Mission Church of San Jose de Tumacacori has been extensively damaged by ground water. Most historic structures do not have dampproof courses between the foundations and walls, so ground water not only erodes the base but rises into the walls through capillary action. As the water evaporates, salts contained in it crystallize in adobe walls and weakens them. If the adobe has been treated with a "preservative," the salts may crystallize between the treated and untreated zones and cause the treated portion to fall off in chunks. Thus, many of the "preservatives" that have been used in the past actually caused greater damage than did natural weathering processes.

*Clifton, J. R., Preservation of Historic Adobe Structures—A Status Report, Nat. Bur. Stand. (U.S.), Tech. Note 934, 35 pages (Feb. 1977) SD Catalog No. C13.46:434, 85 cents. Copies are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Add 25 percent for foreign mailing.

"In general, I am negative about the past history of preservatives," Clifton states.

The traditional approach of protecting adobe walls has been to coat them with some type of material. Many different types of coatings—paint, whitewash, plant extracts, blood, or egg albumen—have been used. None of these form a durable waterproof film; instead, they form thin skins that are vulnerable to scratches and abrasion, and tend to flake, peel, and blister.

Other preservation methods include injecting chemicals into the adobe, says Clifton, but only limited success has been achieved. Similar to the case of coatings, impregnation of the adobe surface has had a negative effect on its durability. Because the treated and untreated portions have differing chemical and structural properties, moisture or temperature-induced stresses occur which can result in cracking. Thus, if moisture enters the adobe, the treated shell may slough off.

The Park Service does not want to restore the historical structures but wants to preserve them as they are now, says Cattanach. Preservation techniques that might be acceptable for new adobe often discolor the historic material.

"We are trying to find a preservative which would work on adobe without the side effects of discoloration, cracking, peeling, or flaking," says Dr. E. M. Winkler, a geologist at the University of Notre Dame. Winkler worked at NBS last summer when the project began and is now continuing his research on a contract basis. He is an expert on stone weathering and sees this project as a "new and extremely complex problem to be solved."

"Right now all we can tell the Park Service is 'don't use any preservatives now'," he says. "All the ones that have been developed have deleterious side effects. We are flexible, however, and are experimenting with all kinds of solvents and oils. We want to find something that is easily available and can be used without having to mix sophisticated, possibly toxic chemicals. We want something which can be applied inexpensively with a paint brush or spray gun. It is difficult to say whether we will find anything that works. It might be that after all the tests, we will still have to tell the Park Service not to use any preservatives."

"We may have to decide whether we should let nature take her course or risk the use of a preservative," adds Cattanach.

Linseed oil diluted with mineral spirits seemed to be a promising solution and worked well on an adobe soil from Maryland, according to Winkler.

CASA GRANDE

One of the historic sites the National Park Service wants to preserve is Casa Grande in southern Arizona.

Casa Grande is part of a mysterious American legacy left to us by its builders, the Hohokam. This stone-age people, thought to be ancestors of the Pima Indians, deserted their walled villages around 1450 A.D.—for reasons unknown to us.

Casa Grande was located in one of those villages, and it compounds the mystery. The "Big House" is an architectural oddity, dissimilar to other Hohokam structures. What was its purpose?

Possibly it was a fort or a watchtower, say some archaeologists. But there is no evidence of warfare, and what was there to watch? Certain openings in the upper walls have led to still another theory: It might have been an astronomical observatory.

Whatever it was during the time of the Hohokam, Casa Grande is today a deteriorating adobe heritage. Damage has been retarded by steps taken to preserve the ruin. In 1891 it was stabilized with bricks, cement, and wooden beams to brace and support the crumbling walls. A large steel canopy was erected in 1932.

But deterioration continutes, and in an area with an annual rainfall of a mere 15 centimeters or less, water is still the main cause. In one or two fierce storms a year, driving rain and accumulated ground water continue to damage Casa Grande and other historic adobe buildings.

When it was applied to adobe soil from the Southwest, however, discoloration resulted. "I didn't realize the composition of adobe soil could make such a big difference," remarks Winkler.

Because the composition and structure of adobe soil are so important, NBS is characterizing adobe from three historic structures and identifying existing methods which could be adopted as standards for characterizing the chemical and mineralogical compositions of adobe from differing locations.

Carl Robbins, a research chemist in the NBS Institute for Materials Research and Dr. Paul Brown, a research materials engineer in the Center for Building Technology, are determining the chemical and mineralogical compositions of the adobe. The techniques they are using include x-ray diffraction, differential thermal analysis, thermogravimetry, and infrared spectroscopy. With other tehniques, such as mercury intrusion and scanning electron microscopy, they are determining the important microstructural features of the adobe—pore size distribution, porosity, particle size distribution, and particle shape. They will recommend specimen preparation and testing conditions for each instrumental method so that other laboratories can duplicate the testing procedures.

The strength of adobe depends on how its dfferent constituents—clay, pebbles, silt, and sand—are distributed. If there are too many pebbles, for example, the adobe is weak and can be badly damaged by rainwater, says Brown. Clay is the bonding agent in the material and, according to Robbins, there is often little clay in the adobe of old structures, probably because it has leached out.

After the structural features of the selected adobes have been characterized, the adobe is gound into a powder and x-rayed by Robbins. These x-ray powder patterns "fingerprint" the particular types of adobe, Robbins explains. The Park Service can use these fingerprints to find soil that is the same as the historic adobe. If they want to patch a structure, they can analyze soil in the nearby area and see if its fingerprint matches that of the original material. If it is the same, it can be used for repairs.

"If the adobe is not the same as the original, then decay does not proceed at the same rate and the integrity of the structure is lost," says Cattanach. "There is not one technique that will solve all these problems. If there is water in the wall, we need to know how much water there is and its source before we can decide on the best preservation technique for that particular structure."

Clifton is developing simple, standard tests and methods to measure the amounts of moisture and salt in the adobe. A high salt content in an adobe wall indicates that ground water is causing trouble and specific solutions can be applied to this problem. He is also developing standard tests and methods to measure the important mechanical properties of adobe to determine the effects of moisture on these properties.

The research carried out at NBS and other institutions will give a better understanding of adobe soils, not only for the sake of preserving them but also to help people who use adobe today in construction, says Clifton. Adobe is by no means an obsolete building material and is frequently used in arid regions like Iran, Egypt, India, Mexico, and the southwestern United States. Adobe preservation is attracting increased attention and a symposium on the problem was recently held in Iran.

NBS researchers believe that their work will have a significant worldwide impact on adobe preservation technology. □

The State of NBS

This sundial, which commemorates the first three directors of the National Bureau of Standards, is located at the Bureau's Gaithersburg, Maryland, site. The latest generation of atomic clock systems is found in the NBS Boulder, Colorado, laboratories. Together, they represent not only the evolution of timekeeping but also the contributions of NBS in its time.

Part 1: Technical Quality and Problem Solving

by Acting Director Ernest Ambler

The following is a portion of Ambler's 1977 "State of the Bureau" address to the staff of the National Bureau of Standards delivered on February 2. The conclusion of his talk will appear in the next issue of DIMENSIONS/NBS.

THE distinguishing feature of the National Bureau of Standards is that our outputs are technical, being heavily based upon laboratory research. Our work lies in the fields of measurement, standardization, and the production and evaluation of reliable technical data.

The basis for our mission is to be found in the statutes under which we operate. These statutes assign us specific responsibilities and call upon us to help solve serious national problems. This has always been so. For 75 years NBS has contributed, with distinction, to the solution of national problems. And it has established itself as an outstanding research and development laboratory with a strong reputation for quality.

These two aspects of NBS remain the most important ones for us to build on and improve. But what becomes abundantly clear to anyone who has taken the time to study the history of NBS, is that *both* the problem-solving and the scientific research have moved with the times.

Today, even more than in the past, NBS has the opportunity to make important contributions. Energy and materials are issues of international importance. Public concern with technology in areas such as the environment, nuclear power, and consumer protection is at an all time high. And there is great need to understand the role technology plays in improving our economy. If these problems are to be addressed, we need to get everything we can out of the efficiency that technology can provide. Moreover, if we are to restore confidence and a national sense of purpose, we need to use whatever objectivity and certainty the scientific method can provide. Many of the high-technology industrial companies that we admire have learned how to translate research into product and profit. For us, the analog is to learn how to translate research into public benefit.

But the path from research and development to innovation and diffusion, either in commercial markets or in the social arena, is a long one, with the most difficult and uncertain part lying beyond the stage of successful research. This puts upon us an increasing demand to understand the utility of what we do. In particular, we need to identify and work through those agencies and institutions that use and *amplify* our outputs.

On the whole, I believe NBS is responding well. It has been a good year for technical accomplishments. The custom in these annual reports of past years, has been to speak of many of these accomplishments—out of a sense of both pride and fairness. This year, I am going to adopt a different approach. I have chosen four activities that I shall describe in detail. These are not the only ones I could have chosen, but, they are the ones that I think effectively convey the two necessary attributes for NBS programs—technical quality and problem solving.

The activities I have chosen are:

- The operation of a comprehensive basic measurements program;
- The assertion of our basic mission in an area of federal regulation;
- The design of a new program in response to legislation;
- The rapid formation of an effective task force.

The basic measurements program I shall describe is in time and frequency. Time is one of the most fundamental concepts in physical theory, and its measurement is essential in keeping all our actions well coordinated. NBS is a world leader, with a balanced program, ranging from basic research investigating the fundamental limits of atomic timekeeping, to the development of better ways of telling people what time it is.

Atomic timekeeping started at NBS in 1949. Today, the cesium beam atomic clocks in our Boulder, Colorado laboratories are perhaps the best in the

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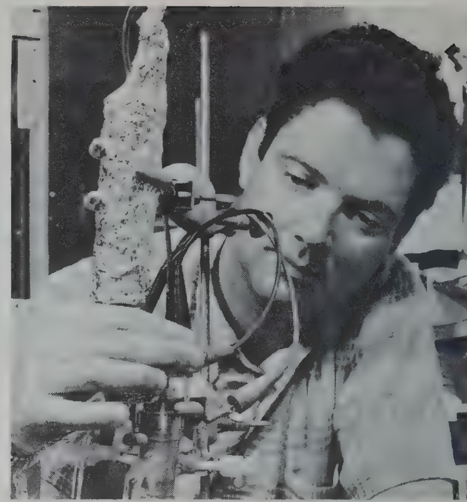
"An important element in the success of any program is how well it couples to the outside world. In the case of time and frequency, that coupling is close and continuous. Staff members work with international organizations and the scientific community. They provide consulting services, and they work hard to keep aware of, and ahead of, the needs of a broad spectrum of users."



"This whole program in air and water measurement shows initiative and sensitivity to an important national problem. It is a model of how we can assert our technical authority in an area of federal regulation."

world. But still greater precision is required, and a new hydrogen standard has been developed. This prototype model, which embodies ideas that overcame difficulties with the hydrogen maser, is 10 times more stable than the best cesium clocks.

In the area of frequency measurement, NBS is a pioneer. We have even appeared, for the first time, in the *Guinness Book of World Records:* "Highest Frequency—In November, 1974, at the U.S. National Bureau of Standards, Colorado, D. Jennings, K. M. Evenson and F. R. Peterson measured a frequency of $147.915850 \times 10^{12}$ Hz. This was generated by a helium-xenon laser." This work is more than a tour de force. It is of fundamental importance. For one thing, it greatly extends the range of frequency domain measurements, with their inherently superior accuracy.

Another major accomplishment is the development of a direct-reading laser wavelength meter. This device measures and displays in real time the wavelength of a dye laser to an accuracy of 2 parts in 10^7, and it will thus play an important role in fundamental spectroscopy.

Time, being of universal concern, must be made synchronous around the world. NBS has made many advances in this technology. Recently, we have developed portable rubidium clocks, which are smaller and consume less battery power than any previous clock. We have also made advances that make the actual clock comparisons themselves more accurate. A new system has been developed that measures the difference between two time sources 500 to 1000 times more accurately than previous devices.

So, our achievements in the science and technology of timekeeping are first rate, as is our delivery to users.

Today our radio broadcasts cover the continental United States and the Pacific and Atlantic Oceans. However, useful as these broadcasts are, they do have limitations. As an alternative, we developed methodology and instrumentation for using T.V. broadcasts. Hundreds of calibration labs, and others that need more accurate frequency information, routinely use this new approach. Another new dissemination approach involves use of satellites, and we are working towards a permanent service, WWVS. A dissemination service that has become very popular is our telephone link to WWV. Nearly two million calls were made during 1976.

At the same time that we are developing new and better services, we are making the old ones more efficient. For example, we have automated many of the operations at WWV and WWVH. Doing so has cut operational costs quite substantially, and the money saved has been applied to research on more advanced systems.

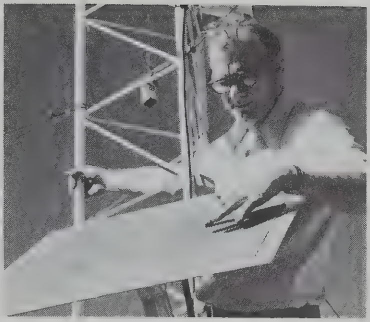
An important element in the success of any program is how well it couples to the outside world. In the case of time and frequency, the coupling is close and continuous. Staff members work with international organizations and the scientific community. They provide consulting services, and they work hard to keep aware of, and ahead of, the needs of a broad spectrum of users.

On top of all that, they run the primary frequency standard, operate a clock bank, and make sure that the signals going out are accurate. They do excellent research themselves, and encouraged by management, draw on the work of other divisions within the Institute for Basic Standards (IBS). I'm proud of this program, for it combines both outstanding research and technical services.

Let me turn now to my second example, the assertion of our measurement responsibility in the regulation of air and water quality.

The Environmental Protection Agency (EPA) exerts leverage and induces change through the regulatory process, and the bulk of their regulations set quantitative limits on various pollutants. Now, quantitative limits of compliance, by their very nature, require the test of accurate measurement.

NBS recognized that we could and should play an important role in the campaign to improve environmental quality. We had to convince EPA that since measurement accuracy was a critical element in many of their programs, NBS would have to make a major contribution. Our early relations with EPA involved as much education as application. And I mean education on both sides. We fostered within EPA an understanding and appreciation of just how



difficult it was to achieve accuracy in measurement. In turn, they alerted us to the necessity for timely response, under Congressional pressure, to regulations that affect the health, safety, and well-being of all Americans.

Today, our work is an important part of EPA's total program. Our technical successes have been most impressive. For example, we have developed measurement techniques and standards for such substances as SO_2, NO_2, hydrocarbons in air, carbon monoxide and a host of radioactive substances. Many EPA regulations which cite specific measurement techniques now specify use of NBS standards.

Faced with major problems on many fronts, EPA operates by applying known technology to the solution of immediate problems. It is an NBS role to develop newer and better measurement technology. As an example, I will describe our work in micro-Raman spectroscopy.

Raman spectroscopy is a very powerful analytical tool. The spectrum produced by light scattering is unique for every irradiated molecule, and provides a convenient means of identifying unknowns. The whole field received a great stimulus by the invention of the laser.

In 1974, the Air Force asked us if Raman spectroscopy could be applied to the identification of single particles smaller than 10 micrometers in diameter. By experiment, we rapidly showed that the job could be done, and then we built an optimized instrument. The schematic shows the device as it exists today. In broad terms, light from an argon-krypton ion laser is focused down on a spot as small as 2 micrometers in diameter. The particle being investigated is placed at this focus. Light scattered from the sample is collected, resolved, and measured.

This instrument is now being used in a variety of applications. For example, in the examination of urban dust samples it can distinguish between various sulfate particles. This is important, for while epidemiological evidence establishes the toxic effects of sulfur compounds in the atmosphere, it is inconclusive as to whether sulfur dioxide or sulfates are more dangerous. Thus, not only is the concentration of sulfur dioxide in the atmosphere important, the kinetics of its conversion to sulfuric acid and then to sulfates are equally important.

Also, this instrument can be very significant in some toxicological studies. We have used it to identify asbestos fibers on the basis of spectral characteristics. Such fibers are known to induce tumors in the lungs.

In these, and in other ways, we have been able to extend the technique of Raman spectroscopy into a whole new area of usefulness. We have a new tool with which to explore the physics and chemistry of particles of micrometer and now sub-micrometer size.

This whole program in air and water measurements shows initiative and sensitivity to an important national problem. It is a model of how we can assert our technical authority in an area of federal regulation. To do so requires not only technical excellence and credibility, but also persistence in building necessary institutional relationships.

For my third example, I want to talk about a specific legislative assignment and the outstanding manner in which we designed a responsive program. It was a first rate job in program planning.

The Federal Fire Prevention and Control Act of 1974 was passed in response to the fire problem here in the United States. We have the highest per capita rate of death and property loss from fire of any industrial nation. Twelve thousand Americans are killed, 300,000 injured, and nearly $4 billion worth of property is destroyed by fire every year. It has become a national goal to reduce those fire losses by 50% in a generation. The Act directed the NBS Center for Fire Research to study the following traditional areas:

- Physics and chemistry
- Dynamics
- Combustion Products
- Early Stages and Detection Technology
- Behavior of Fires in Buildings
- Hazards in Transport and Use

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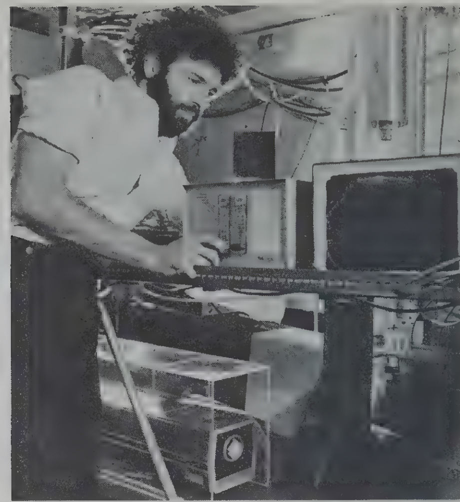
"One thing I find so satisfying about the fire program is that its plan is the result of systematic analysis. Starting with the requirements of the law, the highest priority needs were identified and a research program was devised to meet these needs."



- Design Concepts
- Others

In addition to these traditional areas, the Act authorized the Center to carry out investigations into areas previously untouched by NBS:

- Toxic Substances
- Trauma
- Tests for Pathology
- First Aid Methods
- Arson
- Stress on Fire Fighters
- Other

As you can imagine, the opportunities for research were infinite—and the funds were not. In order to use our resources most effectively, the Center developed a research plan. The plan identifies how fire losses (particularly deaths) are occurring, defines how research can be aimed at reducing the losses, and sets priorities for action.

"My last example concerns our rapid response to an urgent federal problem. Specifically, we provided technical information concerning the welds used along the Trans-Alaskan Oil Pipeline to the Department of Transportation."

There are six factors which are common to every fire: loss, place, time, ignition source, spreading agent, and direct cause of loss. The staff within the Center identified various scenarios for fire loss and assigned probabilities to each. The most probable and serious scenario, for example, is death occurring in a residence, at night, from cigarettes igniting upholstered furniture. The actual cause of death is inhalation of smoke and gas.

The technical responses or intervention strategies, which can be used to break the chain leading to fire loss, are divided into four categories: ignition control, control of spread and growth, detection/suppression, and protection of people. Each project within the Center is directed at one or more of these intervention strategies. For example, in ignition control, a flammability standard for upholstered furniture is one way to substantially reduce deaths from smoldering combustion of furniture. (Nearly 15% of all fire deaths occur this way.) Researchers have developed tests which will form the basis for the new standard. One of these is a cigarette ignition test for classifying upholstery fabric.

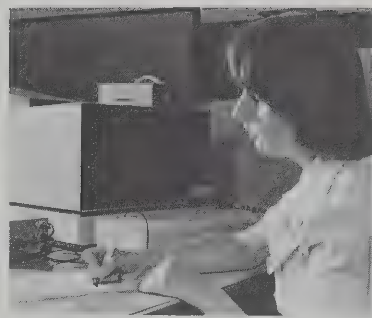
In order to control the spread and growth of fire, we must first understand how it develops in a single room—this is known as the compartment fire problem. Work is underway to develop a mathematical model of fire growth in a compartment. This combines material properties, such as heat release and flame spread, with geometric and weight factors.

If a fire occurs, another way to reduce losses is to detect it and to put it out while it's in its *early* stages. Underwriters' Laboratories, the largest national laboratory testing for safety, has recently adopted a new smoke detector standard based almost exclusively on work done at NBS. Since fire officials caution consumers to purchase only those detectors which meet the UL standard, NBS work has a direct impact on the public. Protecting people also involves the proper selection of materials. Toxic gases produced by burning materials account for approximately 80% of all fire deaths. The Center conducts a program to study what gases are produced by what materials, and to develop tests to rank materials by the toxic products they produce.

One thing I find so satisfying about the fire program is that its plan is the result of systematic analysis. Starting with the requirements of the law, the highest priority needs were identified and a research program was devised to meet those needs. I find it heartening that those most familiar with the problems of reducing fire losses use our results and give the NBS program high marks.

My last example concerns our rapid response to an urgent Federal problem. Specifically, we provided technical information concerning the welds used along the Trans-Alaskan Oil Pipeline to the Department of Transportation (DOT).

The Pipeline, which runs 1300 kilometers from the oil fields at Prudhoe Bay to the port city of Valdez, is a vital part of our plan to reduce dependence on imported oil. Built by the Alyeska Pipeline Service Company, the line, which will go into operation later this year, has a capacity of 2 million barrels a day. Building the pipeline was a major undertaking. The engineering problems were formidable, the terrain spectacular, and the environment most demanding. About half of the line is above ground and half is buried. It passes under 350 rivers and streams and over several major mountain ranges.



Welding plays a key role in the construction and continued integrity of the pipeline. Some 50,000 individual sections of pipe, 1.2 meters in diameter, were joined by welds. DOT specified that these welds must meet certain standards, and that each weld be inspected by x-ray techniques.

Problems with the quality control of field-made welds came to light soon after construction began. Eventually it was disclosed that a significant number of welds contained defects larger than permitted by the DOT regulations.

Anticipating the need for expert NBS advice, the chief of the Metallurgy Division alerted me to our opportunity. I asked the directors of the Institute for Basic Standards (IBS) and the Institute for Materials Research (IMR) to identify a team that would be able to respond to this problem. In a very short time, nearly 50 people from the NBS Gaithersburg, Maryland and Boulder, Colorado laboratories were brought together in a pipeline task force. Thus we were already in stride when DOT requested our technical assistance in June 1976. In brief, our technical involvement fell into the broad areas of fracture mechanics and evaluation of radiographic data. A great deal of lab work had to be done in a very brief time. Among many other things, Boulder personnel measured static fracture toughness and in Gaithersburg, field-made radiographs were analyzed.

On September 1, 1976, Alyeska submitted a waiver request on 612 welds to DOT. All the questionable welds contained defects other than cracks. The Alyeska claim was that these defects would not jeopardize the integrity of the welds nor the safety of the pipeline. They supported their claim by use of fracture mechanics. We faced a major task in verifying the validity of fracture mechanics and made a significant contribution. We also did a great deal of work in assessing the measurement errors associated with x-rays made under field conditions. Our 2-volume, 318-page report went to DOT on October 18. Using our results and other resources, DOT ruled that only 3 welds would be exempted from the standard. All other welds had to be repaired, a difficult, costly process. NBS work played a key role in permitting DOT to base their regulatory ruling on a sound technical foundation.

This major project took 4 months from start to finish, indicating very clearly that NBS is a can-do organization. It was an excellent example of the role NBS can and should play as an unbiased interface between private organizations and federal regulatory agencies. In a very sensitive situation we were able to do our job and maintain the respect and goodwill of all parties. In addition, the NBS people involved were caught up and excited by this challenge to resolve a difficult technical problem under a stringent deadline.

Throwing our resources into this project had another important result. It helped sharpen the focus of our own programs. For example, one question asked by DOT was whether an ultrasonic inspection technique, instead of x-radiography, could be used on buried welds. The answer was no, and the need for standards in both areas became even clearer. It also became very clear that our work in fracture mechanics should be expanded. Thus, the perceptions gained in this work will be a definite factor in shaping our future programs.

By means of these four examples, and let me repeat, that these are not the only four I could have selected, I have illustrated:

- A comprehensive basic measurements program;
- Work with a regulatory agency;
- The design of a new program; and
- A timely and effective response to a national problem.

These examples, are in my opinion, models. In each case, the program manager displayed understanding *both* of the environment in which the program operates *and* of the kind of research required. The result is effective public service, and that is what we are here to provide. □

Next month, Part II of Ambler's address will cover the environment in which NBS operates: policies as mandated by Congress and the Administration, policies developed internally, and the NBS budget.

HOW SWEET IS IT?

To set a new international standard for the purity of raw sugar, chemist Arthur Cummings* measures the "optical rotation" of sucrose in water to redefine °S (the sugar degree), the scale by which buyers and sellers judge the composition of sugar.

White sugar is almost pure sucrose, usually about 99 percent pure, according to Cummings. Other substances in raw sugar could be glucose, fructose, or rafinose. These are not harmful but are considered impurities. Fructose is the predominant sugar in corn syrup, while fructose and glucose are predominant in honey and fruit juices. The higher the percentage of sucrose in raw sugar, the higher the price of that sugar in the marketplace.

"We use the purest sucrose we can find and analyze its impurities," says Cummings. "In this way when we measure the optical rotation in a sugar solution we will know how much of the rotation is caused by sucrose. This measurement then becomes the standard on which to base the purity of sugar."

German research from 1962 to 1974 on the purity of sugar indicated that the standard, which has stood since the turn of the century, needed to be changed. The United States wanted to test Germany's findings before accepting a new standard and Cummings is doing just that.

"A new measurement standard will not really affect the average person," says Cummings. "The change will only be about 0.03 percent and on one bag of sugar that is not going to make much difference in price. But sugar companies buy tons or shiploads, and it could mean the difference of millions of dollars to them."

Cummings' work is being sponsored by a grant from the U.S. Sugar Association to the International Sugar Research Foundation (ISRF). ISRF sponsors many types of sugar research, for example, a study on the effect of sucrose on diabetes. ISRF turned to NBS for assistance on the sugar purity study because none of the sugar companies had the facilities for such highly sophisticated research.

Cummings uses a polarimeter to measure the optical rotation of sucrose. A beam of polarized light is passed through the optically active solution of sucrose and water, and the angle of the rotation of light is measured to within a second of an arc.

Cummings illustrates how critical a measurement is involved by pointing out that, "If your arm were five kilometers long and you moved your fingers 2.5 cm, your shoulder would move through a second of an arc."

To measure the angle to this degree of accuracy, Cummings needed a supersensitive instrument. No polarimeter on the market could meet the requirements of the project. So Cummings helped design a new polarimeter, which becomes the property of the Bureau and will benefit many other NBS researchers.

Prior to joining the ISRF, Cummings did postdoctoral work at the University of Utah on fast reaction kinetics. One of his projects that made use of polarimetry was the study of the helix coil transition rate in polyglutamic acid. In certain pH concentrations, the helix of this long polymer unwinds and rewinds (transition). This sort of transition, which occurs in other similar molecules in the body, is important in biological and biochemical research.

In September 1975 Cummings began his association with NBS. His work here will continue until December 1977, and in 1978 he will present the results to the International Commission on Uniform Methods for Sugar Analysis. He expects a new standard for the purity of sugar to be adopted. DV

*Cummings is working at NBS as a Research Associate under the sponsorship of an industry organization, the International Sugar Research Foundation, supported by dues and grants from the companies with the sugar industry. The Research Associate Program has brought researchers from all areas of industry to NBS labs for over 50 years to work on projects of mutual interest—for mutual benefit. For information contact Peter de Bruyn, Room A402 Administration Building, National Bureau of Standards, Washington, D.C. 20234. Phone: 301/921-3591.

COPPER "BENCHMARK" STANDARD REFERENCE MATERIALS

by George A. Uriano and Robert E. Michaelis

"Standard Reference Materials (SRM's) are well-characterized, stable, homogeneous materials produced in quantity for which the values of one or more physical or chemical properties such as trace elemental composition are numerically expressed along with their associated uncertainties.

"Benchmark" SRM's are so designated because they serve as the essential anchor points for the calibration of many instrumental measurement systems.

Impurity elements and their concentration levels in refined copper have a profound effect on such properties as electrical conductivity and thus on product performance in a number of energy-related applications. For example, the presence of as little as 0.005 percent of such impurities as iron in copper wire can reduce its electrical conductivity by 4 percent, thus resulting in serious energy transmission losses.

Chemical composition specifications for unalloyed copper products have become so severe that disputes between producers and consumers are frequent with respect to the measured values of the impurities contained. To promote measurement compatibility and standardization in the multi-billion-dollar-a-year copper industry, NBS was asked to produce and provide accurately characterized trace elemental Standard Reference Materials. The urgent need for NBS SRM's of unalloyed copper is well documented by a variety of groups, including copper producers, electrical manufacturers, power generation and transmission firms, telephone and associated firms, nuclear energy utilities, voluntary standards organizations, professional societies and other government agencies.

Uriano is deputy chief and Michaelis is chief coordinator of the NBS Office of Standard Reference Materials.

Since 1972 NBS has been cooperating with the American Society for Testing and Materials and with a large network of industrial laboratories in an effort to produce a series of 12 unalloyed copper "benchmark" SRM's. The project is being managed by R. E. Michaelis and by J. G. Hust of the NBS Cryogenics Division in Boulder, Colorado. When completed the SRM's will take a variety of forms and will be certified for chemical composition, including 25 to 30 trace elements covering the concentration range needed by the copper industry to control the quality of unalloyed copper products used throughout the world. More than 70 participants cooperated with NBS in the planning stage of this major project; 16 companies provided the base materials and 22 laboratories cooperated in the analytical program for certification. More than 20 scientists in the NBS Analytical Chemistry Division and NBS Cryogenics Division are involved in this effort. I. L. Barnes is coordinating the work in the Analytical Chemistry Division. The program also has active participation from industry and government in South Africa and valuable input from Canada, South America, and the European Economic Community.

Based on industrial needs, documented largely under the auspices of ASTM Committee E-2 on Emission Spectroscopy, NBS embarked on a comprehensive plan for preparing the SRM's. The original plan called for the preparation of the materials, both in chip and in rod form. As the planning developed, it was clear that, to achieve the requisite homogeneity, some of the materials could be prepared only in chip form. A further modification was made to provide some materials in disk form that could be used in optical emission and x-ray spectrometric methods and analysis.

At NBS methods of demonstrated accuracy were employed for as many elements as possible in the belief that once some of the SRM's had been issued, the characterization of the remaining SRM's could be expedited by measurements made in the cooperating laboratories.

In July 1976 NBS announced the availability of the first three SRM's of unalloyed copper characterized for their chemical composition. These are SRM's 394, 395, and 396. They are in the form of small chips designed primarily for use in optical emission methods of analysis, but they may also serve in the development of other new or improved trace analytical techniques. The need for such SRM's was further clearly demonstrated by the spread of the measured results obtained in the cooperating laboratories. In some instances they disagreed with each other and with the "accurate" NBS values by 100 to 300 percent.

Certified values, together with their estimated uncertainties, are given for antimony, arsenic, bismuth, copper, iron, lead, manganese, nickel, silver, sulfur, tin, and zinc. Recommended values are given for chromium, cobalt, selenium, and tellurium. Additional information on the composition is provided for cadmium, gold, and oxygen, and conservative "upper limits" are given for aluminum, calcium, magnesium, silicon, and titanium. The current certifications for SRM's 394-396 give the present best estimate of the "true" values based on the results of the cooperative analytical program.

Work is under way now at NBS for further characterization of SRM's 394, 395, and 396, most of which is being accomplished concurrently with the certification of the other benchmark standards. The rod counterparts of the chip materials—SRM's 494, 495, and 496—are expected to be available sometime this summer.

The analytical program for certification of the copper benchmarks has been one of the most difficult ever attempted at NBS, mainly because some trace analytical methods generally applicable to other matrices could not be used with the copper matrix.

The copper benchmark SRM project illustrates the many important industrial applications of SRM's, particularly in the area of trace analysis. The project has gained worldwide interest and should foster more effective international standardization.

STAFF REPORTS

COVER STORY:

THERMAL NEUTRON XERORADIOGRAPHY

NBS scientists have developed a method which allows use of the xeroradiography process for the first time to produce a thermal neutron radiographic image. This work is part of a cooperative project between scientists at the Reactor Radiation Division and Dr. William Parker of Reed College, Portland, Oregon, to investigate and develop new beam imaging methods for neutron radiographic nondestructive evaluation.

Donald A. Garrett, Reactor Radiation Division, A108 Reactor Building, 301/921-3634.

The unique interactions which take place between thermal neutrons and constituent nuclei of materials and components often make it possible to visualize macroscopic details that are difficult, if not impossible, to detect with other radiographic methods.

It is quite possible to penetrate large thicknesses of such dense materials as lead to visualize light materials such as rubber, hydrogen, or plastic.

To produce neutron radiographs through xeroradiography, we found it necessary to place a gadolinium oxysulfide neutron converter close to a selenium imaging plate. (Neutrons are nonionizing and produce no image on the selenium screens used for normal x-ray xeroradiography).

With our technique, an image is produced through the following process: Neutron capture in gadolinium causes internal conversion electron emission, the mechanism which produces the image on the selenium plate. Since this process is a differential one—i.e., there is a starvation of graphite particles at an image density gradient—an edge-enchanced image is produced without the use of electronic processing.

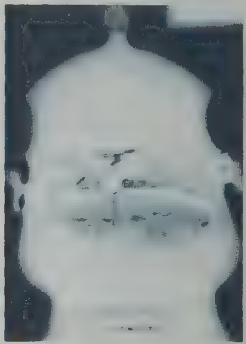
In cooperation with the Smithsonian Institution scientists of the Freer Gallery, we have used the process to radiograph ancient Chinese leaden and bronze ceremonial urns to visualize internal structural details and corrosion. Futher developments and applications of the technique are underway.

The Chinese Yu shown here is a ceremonial vessel made of lead dating from the Western Chou period, approximately 1,000 B.C. It is part of the collection of the Hermatage Foundation Museum, Norfolk, Va. and is now on loan to the Freer Gallery of the Smithsonian Institution in Washington, D.C.

Members of the Smithsonian brought the Yu to NBS, where Bureau researchers used it to test their new nondestructive evaluation technique—neutron xeroradiography. The result (shown in color) can be compared with the photograph and the x-ray.

Unlike x-rays, neutrons can penetrate lead. Thus, the radiograph shows the mottled areas between the cap and the vessel where corrosion has sealed the urn. Note too the corroded area near the base. Also visible in the radiograph on the left side is the outline of some material—paper or perhaps fabric—that may have been used in repairing the vessel. Other repair work can be distinguished without the aid of neutrons: Near the center, a triangular portion has been patched, possibly with bronze.

The exact purpose the vessel served and how it was damaged are, of course, matters of speculation. One theory is that this Yu was made for a burial service as one of the items to be included in the grave. The damage could have been done by early excavators, possibly grave robbers, who searched by poking the ground with sharp objects until they struck metal.



POSSIBLE MECHANISM FOR REMOVAL OF HALOCARBONS FROM THE LOWER ATMOSPHERE

NBS researchers report that solar radiation of wavelengths which reach the earth's lower atmosphere (troposphere) can break down fluorocarbon 11 (CFC_3, fluorocarbon 12 (CF_2Cl_2) and carbon tetrachloride (CCl_4) if the chemicals are first adsorbed onto sand or quartz. The findings provide the first laboratory evidence that a mechanism exists for breaking down these industrially important halocarbons by light in the troposphere. The extent to which the breakdown of halocarbons on surfaces may actually remove these substances from the troposphere before they reach the upper atmosphere is unknown and remains to be explored.

Pierre J. Ausloos and Richard E. Rebbert, Physical Chemistry Division, A243 Chemistry Building, 301/921-2783.

In studying the photochemistry of halocarbons, we noticed that at 313 nanometers the extent of decomposition of carbon tetrachloride was significantly greater when we performed experiments in a quartz vessel than in a glass vessel. It was then brought to our attention that some measurements of the concentration of carbon tetrachloride in the troposphere had been carried out by the British scientist J. E. Lovelock. The concentration of this halocarbon was significantly lower off the coast of west Africa near the Sahara desert than in other regions of the eastern hemisphere. It occurred to us to look at what happened when the halocarbons and sand were placed in direct contact and irradiated with light of the wavelengths which penetrate to the surface of the earth.

Consequently, we purchased ordinary clear "sea sand" from a local scientific supply house and placed it in a glass reaction vessel. Carbon tetrachloride was added, and light of 366 nanometers (mercury resonance line) was used to irradiate the material adsorbed on the sand. The experiments were carried out at room temperature so that the conditions of temperature and light energy were

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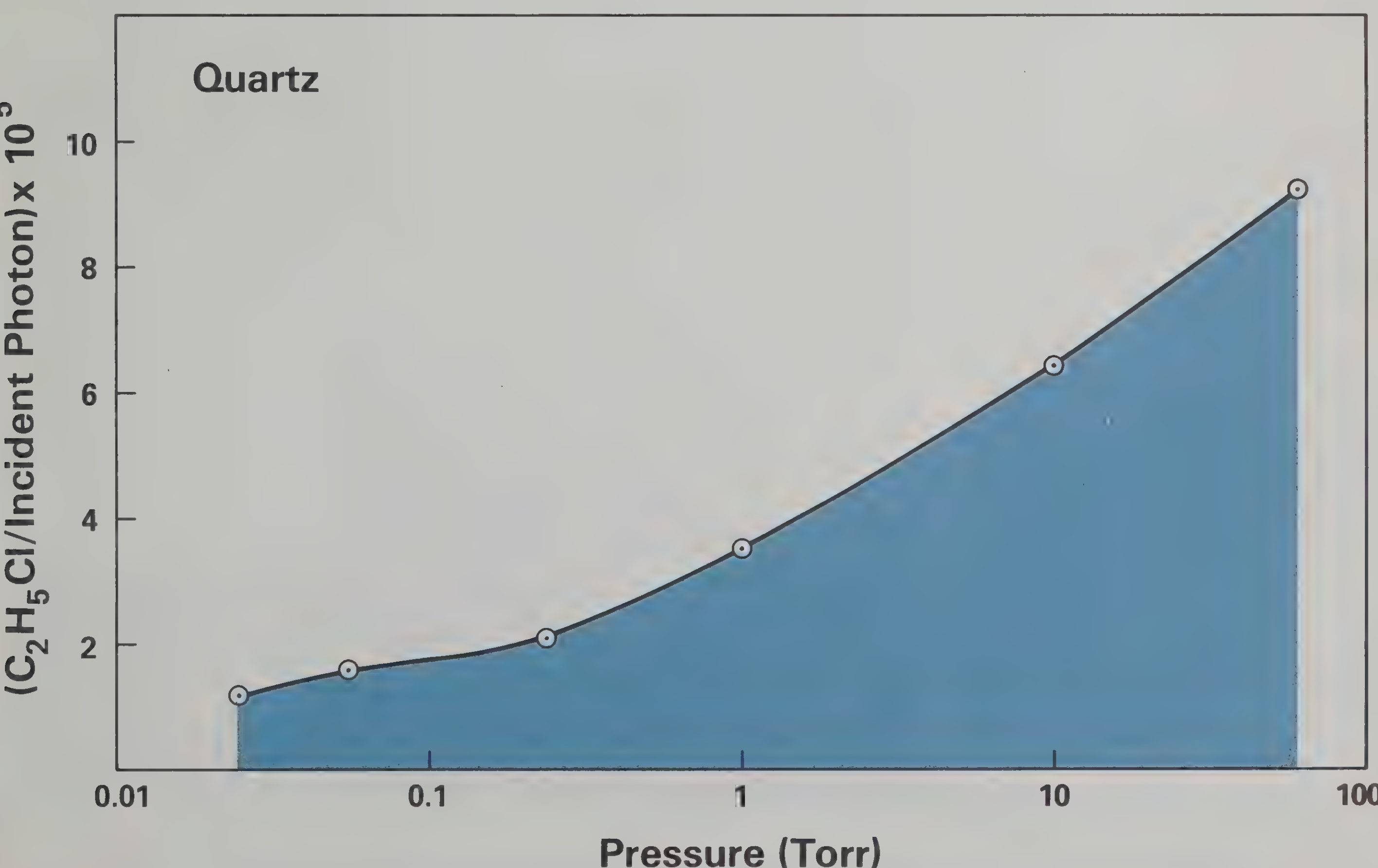
Figure 1—*Effective Pressure on the Formation of C_2H_5 from the Photolysis of CCl_4-C_2H_6 on a Quartz Surface wtih Light at 366 nm.*



essentially typical of tropospheric conditions. We then measured the reaction products using gas chromatography and found that the carbon tetrachloride not only absorbed the light, but decomposed to form chlorine atoms.

In other experiments, we used sand which was actually collected from north African deserts. This sand, which was high in mineral content, also catalyzed the light-induced destruction of carbon tetrachloride, but through a different breakdown mechanism. This result could account for the sharp dip in the airborne concentration of CCl_4 observed by Lovelock in the vicinity of north Africa.

We found similar light-induced breakdown mechanisms occurring for fluorocarbons 11 and 12 irradiated in the presence of sand, but the destruction of these substances is less efficient by at least a factor of ten than the breakdown of carbon tetrachloride. At 366 nanometers and a pressure of 15 pascals, one molecule of carbon tetrachloride is destroyed for every 10^4 photons of light reaching the sand. Furthermore, fluorocarbon 12 is destroyed less efficiently than fluorocarbon 11.

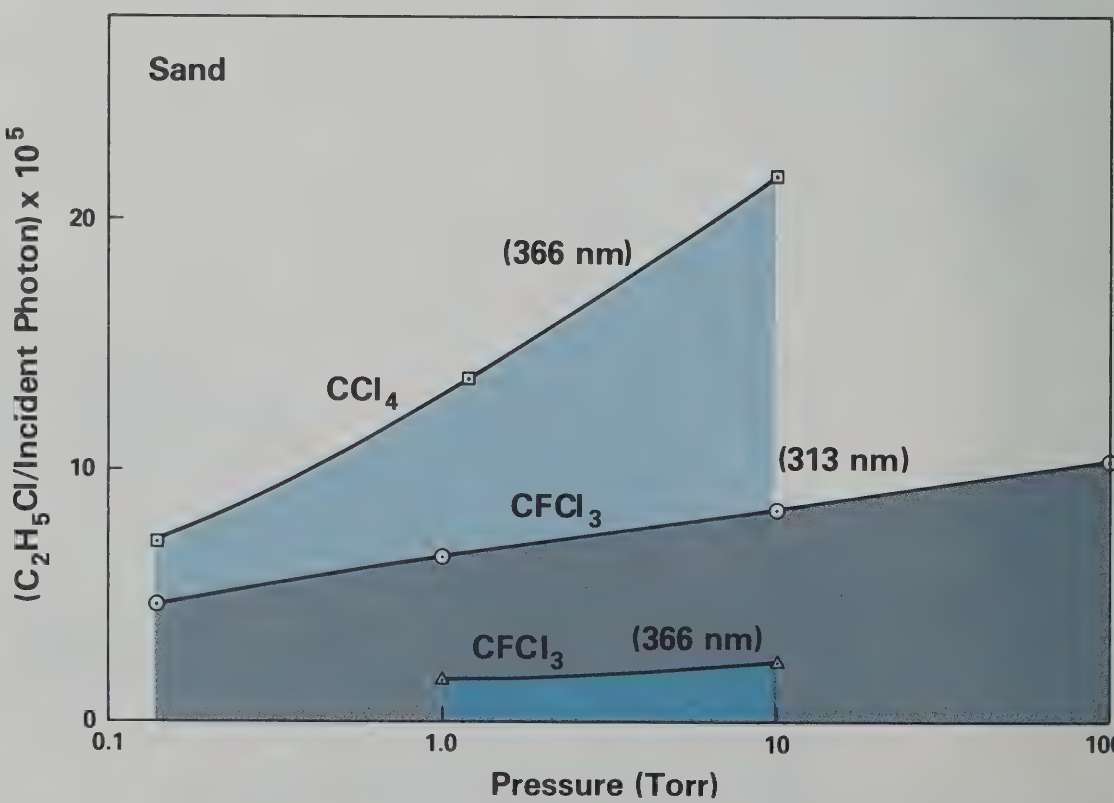
Based on these observations, we believe that scientists interested in measuring the effect of such a removal mechanism in the troposphere should look at carbon tetrachloride rather than the fluorocarbons.

Other specific observations made in the course of this research include:

- Decomposition of the adsorbed halocarbons occurs only at wavelengths whose energy is equal to or greater than the energy (strength) of the carbon-chlorine bond(s) being broken. Irradiation by visible light does not cause decomposition, and there is no effect in the absence of radiation.
- The amount of decomposition is not very sensitive to the pressure of the halocarbon gas above the surface. The pressure was varied by a factor of 500, from 13.3 pascals to 6650 pascals, in these experiments. Experiments at still lower pressures, which would more closely approximate halocarbon concentrations in the troposphere, are now being carried out.
- For any particular halocarbon, the number of molecules decomposed per photon of light reaching the surface increases with an increase in photon energy. Experiments were performed using photons ranging in wavelength from 404.5 nanometers to 313 nanometers.
- The mechanism of destruction observed for a given halocarbon on the service of clean sea sand, silica sand, quartzite or quartz tubing is the same.

We are now carrying out additional experiments to determine the effects of other surfaces and conditions on the breakdown processes.

Figure 2—*Effective Pressure on the Formation of C_2H_5Cl from the Photolysis of CCl_4 and $CFCl_3$ in the Presence of Ethane on Sand at the Indicated Wavelengths.*



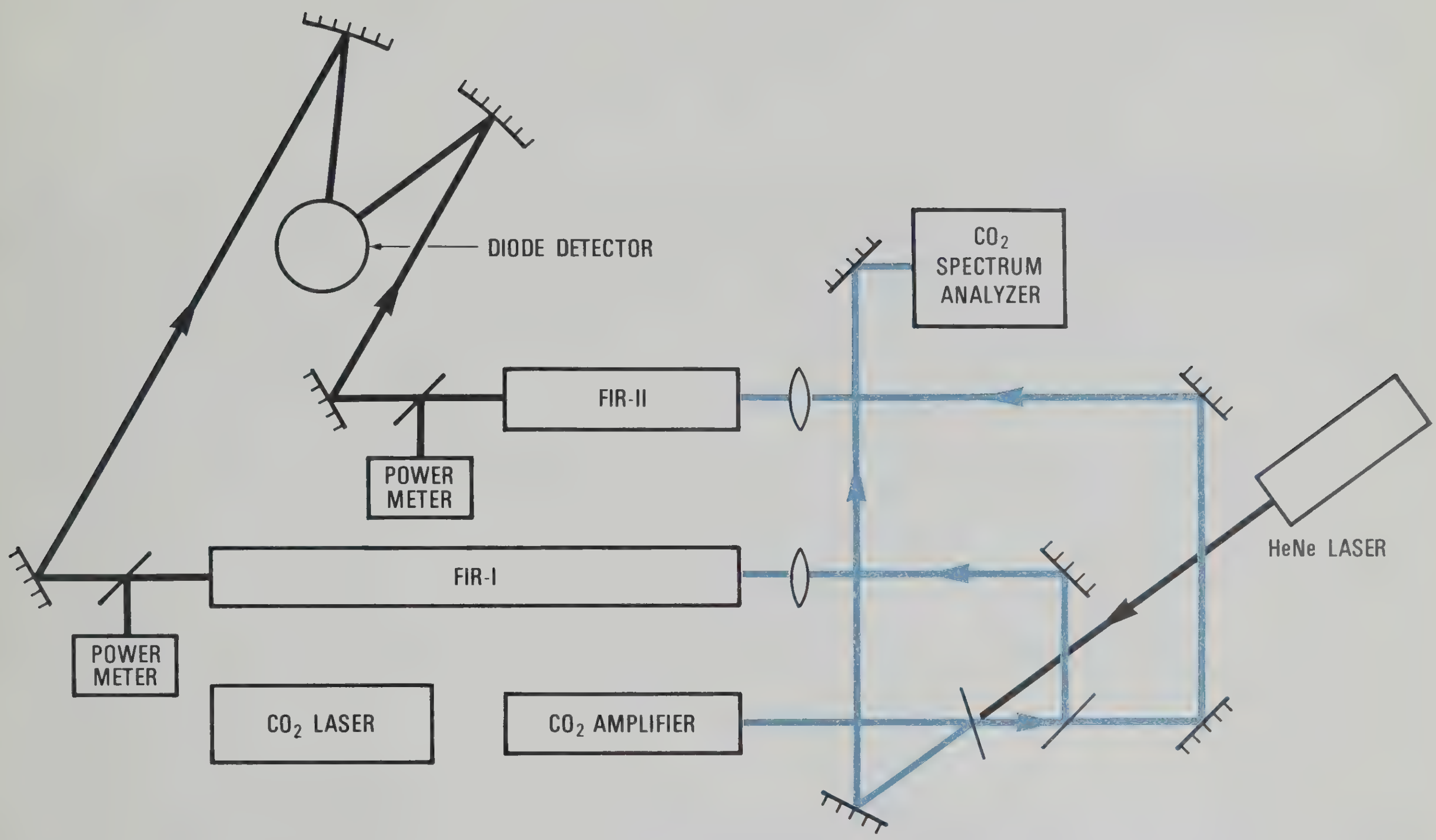


Figure 1—Schematic Diagram of system for heterodyning two FAR-infrared (FIR) Lasers. *The frequency of FIR—II may be tuned by applying an electric field.*

ELECTRICALLY TUNED FAR INFRARED LASERS

Researchers have for the first time demonstrated high-speed frequency tuning of a far infrared (FIR) laser by the application of electric fields. High speed modulation of FIR lasers is needed in order to phase-lock such lasers with no loss of precision to frequencies multiplied upward from the radio frequency region. This capability is necessary for the development of time and frequency standards and certain communications techniques in the infrared and eventually the visible regions of the electromagnetic spectrum.

Samuel R. Stein, Time and Frequency Division, Room 1-2029, Boulder, Colo., 303/499-1000, x3324.

We chose to tune a FIR laser by using electric fields (Stark frequency shift) because this method offers several advantages. It is generally applicable to any lasing medium and does not require introducing any appreciably lossy material into the laser. In addition, it is capable of high speed because the response time can be as short as the time which photons spend in the laser. The FIR laser used in the experiments had a cylindrical dielectric waveguide containing methyl fluoride gas and was optically excited by a CO_2 laser. The line studied was at 496 μm (604 GHz). A dc electric field was applied using copper electrodes both inside and outside of the laser.

The application of an electric field to the gas causes the normally Doppler broadened line to increase in width due to the splitting of the line into a number of components. This broadening causes the frequency of the laser to change due to an interaction with the laser cavity. In order to measure this frequency shift, the output from the tunable laser was mixed with the fixed frequency signal from a second laser using a point-contact metal-insulator-metal diode. A maximum electronic tuning of 500 kHz with a tuning sensitivity of 5 kHz/(V/cm) was observed. Also, a tuning speed (modulation rate) of 100 kHz was realized. Tuning speeds above 10 MHz should be possible.

Through use of this tuning technique, we are now developing a method for phase-locking a FIR laser.

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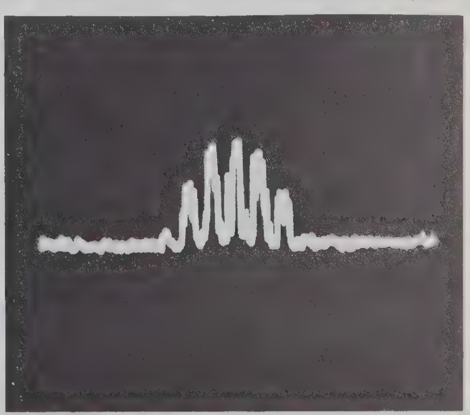

Figure 2—Photograph of the modulation spectrum of the electric field-tuned FAR-infrared laser. *The sidebands are predominantly frequency modulation.*

THE GRAPHIC PEN—AN ECONOMICAL SEMIAUTOMATIC FINGERPRINT READER

NBS, working with the support of the Federal Bureau of Investigation, has contributed to the development of automated systems for fingerprint identification. The automated process consists of reading and digitally encoding the relative positions and orientation of minutiae (the ridge endings and ridge bifurcations in the fingerprint). These data are processed by computer and compared with minutiae data for fingerprints on file. The automated systems have been found to be most effective when the fingerprint impressions are of reasonable quality. Improperly inked or smudged prints and latent (or scene-of-crime) prints are usually of poor quality and not suitable for fully automatic processing.

Raymond T. Moore and James R. Park, Computer Systems Engineering Division, A217 Technology Building, 301/921-3427.

Semiautomatic devices that utilize the superior pattern recognition capacity of humans in conjunction with the accuracy and fidelity of machine recording of minutiae data are being investigated for processing of low quality fingerprints. We are testing the graphic pen, a semiautomated device developed by NBS to encode fingerprint minutiae.

The graphic pen device is shown in Figure 1. An opaque projector is mounted within an enclosure with a project image surface of transparent plastic in the horizontal plane. A piece of translucent copy paper clamped on the transparent plastic provides a surface for the projection of a 10X enlarged image of a fingerprint.

An extensible pen is suspended directly above the image surface from a gimbal assembly that is mounted at the top of the housing. Shaft position encoders used to measure the X and Y displacements of the pen arm have 13-bit resolution. This angular resolution coupled with the length of the extensible pen arm results in a nominal 1-bit change for each millimeter of pen displacement in the X or Y directions on the image surface. Over the limited arc that is required to cover the 256-mm square field of view, only the 8 low order bits of the encoders are used. Over this limited range the departure from linearity is less than ± 0.5 mm, and the

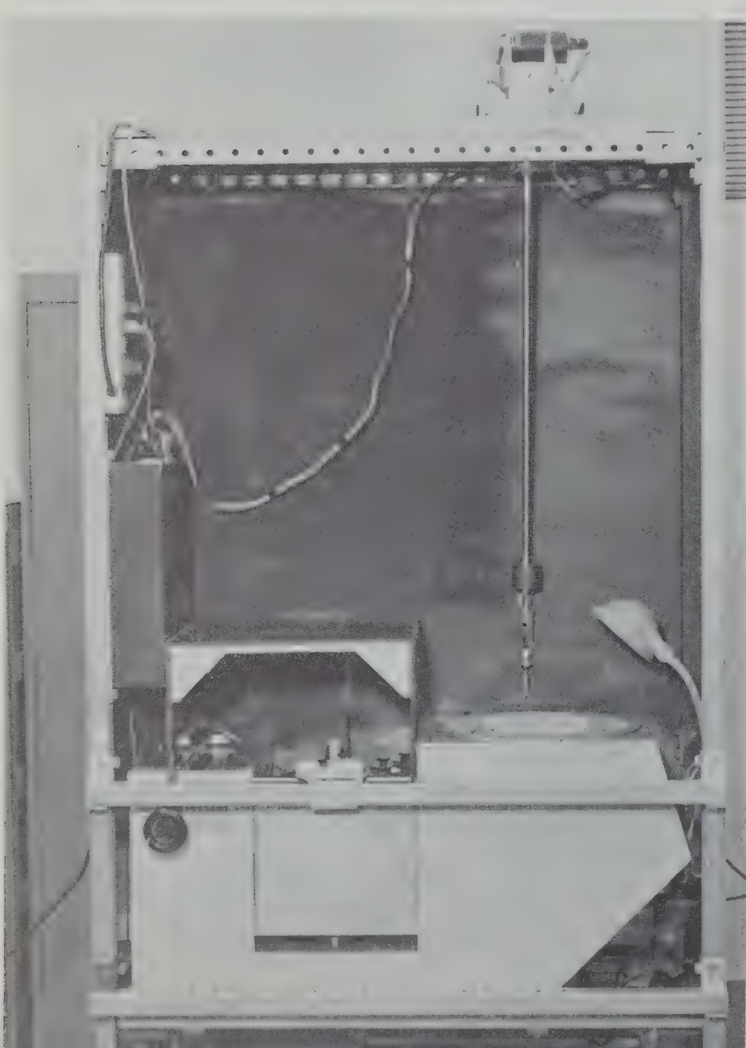

Figure 1—GENERAL ARRANGEMENT OF THE GRAPHIC PEN SHOWING THE OPTICAL PROJECTOR, PEN ARM, AND ENCODER GIMBAL.

Figure 2—LATENT FINGERPRINT AS POSITIONED IN THE IMAGE PLANE BY AN OPERATOR.

use of trigonometric functions are not required. An 8-bit resolution shaft position encoder is mounted coaxially with the pen arm and provides values in accordance with the rotational positioning of the arm.

The graphic pen, operating as an adjunct to the computer terminal, uses the same telecommunications facilities as the terminal. The operator accesses the computer for the program to accept data from the graphic pen and carefully positions the fingerprint image so that the core is located at a designated point in the field of view. The image is rotated to the position which appears most likely to represent alignment of the whole finger with a vertical line.

The operator transmits information to identify the list of minutiae and the classification of the fingerprint to be read and then positions the pen on a minutia (See Figure 2). The direction of the minutia is measured by rotating the pen arm so that an indicator is aligned with the average direction of the local ridge flow. Shaft position encoders provide X, Y, and ϕ (angle of minutia direction with X axis) positional information to the computer on command from the operator. This process is repeated for each of the minutiae that the operator can identify in the print.

The values received by the computer are echoed back and the output displayed on the terminal for a local record. The operator marks the recorded minutiae on the paper on the image surface. The remote computer formats the minutiae data and stores them as a disk or magnetic tape record. The data can then be used as input for a computer search against a master file of machine read minutiae data.

The accuracy of the projection system was verified by comparing the measurements of the magnified image and the object being magnified. Comparison of encoder output values with actual displacements of the pen on the image surface verified the accuracy of the encoding system. Comparisons were made of scaled plots of encoded data with the corresponding markings made on the paper on the image surface.

In limited small scale tests involving closed searches, data read by the graphic pen from latent prints could be matched with data obtained from a mate rolled impression print 90% of the time. The unsuccessful matches could be attributed for the most part to the poor quality of the latent print or to improper print orientation and displacement in reading.

The cost effectiveness of this procedure depends, in part, upon total system performance. One factor to be considered in the evaluation is the time required to read a fingerprint. Typical reading times were observed to be from 6 to 10 minutes and appeared to be a function of operator experience, skill, and dexterity.

The excellent results obtainable with the graphic pen are currently being employed to further the study of matching latent fingerprint data with those obtained from rolled fingerprint impressions.

NEW AIR POLLUTION STANDARD REFERENCE MATERIALS

More accurate measurements of sulfur dioxide, a major air pollutant and health hazard, will be possible as a result of four new Standard Reference Materials (SRM's) issued by the NBS Office of Standard Reference Materials. The SRM's will provide the most accurate means to date of calibrating equipment and methods used by state and local governments to determine if levels of sulfur dioxide from industrial stacks in their jurisdictions are in compliance with federal emission standards.

More than 30 million metric tons of sulfur dioxide are emitted into the atmosphere each year. These emissions result primarily from combustion of fossil fuels and through metal refining. Concentrations of sulfur dioxide as low as 100 micrograms per cubic meter (38 parts per billion by volume) have been proposed as the threshold above which long term exposure to sulfur dioxide can cause increased prevalence of chronic bronchitis in adults.

It is estimated that over 900 major industrial facilities, such as coal-fired power plants, sulfuric acid plants and primary metal refiners will need to be monitored continuously to meet federal regulations. The following SRM's will help insure that measurements of sulfur dioxide made by different agencies and by industry are compatible.

The SRM's and their concentrations in parts per million by volume (ppm) are:

SRM 1661 Sulfur Dioxide in Nitrogen	480 ± 5 ppm
SRM 1662 Sulfur Dioxide in Nitrogen	942 ± 10 ppm
SRM 1663 Sulfur Dioxide in Nitrogen	1497 ± 15 ppm
SRM 1664 Sulfur Dioxide in Nitrogen	2521 ± 25 ppm

Only by accurate measurement of the sulfur content of the fuels in use, of the sulfur dioxide emitted by various sources and, finally, of sulfur dioxide content of the air itself can the total sulfur dioxide problem be understood and controlled. NBS now offers SRM's in each of these areas. In the fuel area NBS offers grades of fuel oil analyzed for sulfur (SRM's 1621-1624) and a sulfur in coal (SRM 1631). For the ambient air monitoring, NBS offers sulfur dioxide permeation tubes (SRM's 1625-1627).

The new SRM's for determining sulfur dioxide in stack gas complete the series of sulfur dioxide reference materials available from NBS. This work was supported in part by the Office of Energy, Minerals, and Industry within the Office of Research and Development of the U.S. Environmental Protection Agency under the Federal Interagency Energy/Environment Research and Development Program.

The SRM's are supplied in aluminum cylinders containing 0.85 m^3 of gas at standard temperature and pressure. The cost is $356 per cylinder.

Purchase orders and additional information about these and other SRM's should be sent to the Office of Standard Reference Materials, Room 311 Chemistry Building, National Bureau of Standards, Washington, D.C. 20234.

CONFERENCES

For general information on NBS conferences, contact Sara Torrence, NBS Office of Information Activities, Washington, D.C. 20234, 301/921-2721.

ELECTRICAL MEASUREMENT SEMINAR

A Low Frequency Electrical Measurements Seminar will be held April 25-28, 1977. This 4-day meeting will present information on the accurate measurement of electrical quantities and the calibration of electrical standards. It will cover the measurement methods used by NBS to establish and maintain the basic electrical units and to calibrate customers' standards or resistance, voltage, current, reactance, and power from direct current up through 100 kHz.

The program will consist of lectures and demonstrations in the NBS Electricity Division laboratories. Emphasis will be on measurement techniques which should be useful to workers in standards and calibration laboratories. Other topics such as solid state devices, data processing and computer automation will also be presented.

For further information contact Ronald F. Dziuba, A247, Metrology Building, 301/921-3806.

CONFERENCE ON CORROSION

A Conference on Corrosion and the building industry will be held May 16-18 at NBS in Gaithersburg, Md.

Corrosion is a continuing problem in the effective use of metals in building construction. Metals are used extensively in buildings—for structural members; concrete reinforcement; plumbing, heating and cooling systems; electrical systems; hardware; siding and roofing; and many other purposes. Corrosion of metals causes economic losses and safety hazards, both of which can have legal consequences. These problems occur even though a well-developed corrosion prevention technology exists.

This meeting seeks to promote a more effective use of corrosion prevention technology in the building industry by bringing together corrosion engineers and architects, engineers and others from the building community. It is sponsored by three organizations with close ties to either the corrosion community or building industry, or to both. They are the National Bureau of Standards, the National Association of Corrosion Engineers, and the Construction Specifications Institute.

The meeting wil be a dialogue between the building and corrosion communities, with the building community acquainting corrosion engineers with the nature and extent of their corrosion problems, and the corrosion community providing information on the technology of corrosion prevention. It is hoped that the dialogue will help solve current problems and suggest areas where new corrosion prevention technology needs to be developed.

The dialogue in this two and one-half day meeting will be stimulated by background talks. These talks will be followed by informal discussions between participants on questions related to the meeting's general theme.

In more detail the program will cover the following topics: Socio-Economic Aspects of Corrosion, Forms of Corrosion, Atmospheric Corrosion, Underground Corrosion, and Protective Coatings; Corrosion problems in Structural Systems, the Building Envelope, Plumbing Systems, Electrical Systems, Solar Energy Systems, and Heat Transfer Systems; and Performance Criteria for Materials Selection. Adequate time will be set aside for an interchange of views and information between meeting participants, speakers, and a panel of experts.

A registration fee of $75 will be charged to all attendees to help defray the total costs of conducting the conference and, its directly related activities. For further information contact: Dr. Jerome Kruger, Corrosion and Electrodeposition Division, B254 Materials Building, 301/921-2094.

CONFERENCE CALENDAR

March 28-31
NEUTRON STANDARDS SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS; contact: European scientists Dr. Horst O. Kiskien, 014/58.94.21, Central Bureau Voor Nucleaire Metingen, B-2440 Geel, Steenweg Naar Retie, Belgium. Other participants contact: NBS, Dr. Charles D. Bowman or Dr. Allan D. Carlson, B119 Radiation Physics Building, 301/921-2234.

April 14-15
10TH ANNUAL SYMPOSIUM ON THE INTERFACE OF COMPUTER SCIENCE AND STATISTICS, NBS, Gaithersburg, MD; sponsored by NBS; contact: David Hogben, A338 Administration Building, 301/921-2315.

***April 18-19**
WORKSHOP ON THE ESTIMATION OF THE PROPERTIES OF FLUID MIXTURES, NBS, Gaithersburg, MD; sponsored by NBS; contact: Dr. Max Klein, A105 Physics Building, 301/921-2533.

***April 20-21**
SYMPOSIUM ON APPLICATION OF SPACE FLIGHT IN MATERIALS SCIENCE AND TECHNOLOGY, NBS, Gaithersburg, MD; sponsored by NBS and NASA; contact: Dr. Elio Passaglia, B266 Materials Building, 301/921-2822 or Dr. Shirleigh Silverman, A402 Administration Building, 301/921-3591.

April 23-26
COMPUTERS IN ACTIVATION ANALYSIS AND GAMMA-RAY SPECTROSCOPY, NBS, Gaithersburg, MD; sponsored by NBS, American Nuclear Society, American Chemical Society, ERDA and U. of Puerto Rico Nuclear Center, contact: B. Stephen Carpenter, B108 Reactor Building, 301/921-2167.

April 25-28
LOW FREQENCY ELECTRICAL MEASUREMENTS SEMINAR, NBS, Gaithersburg, MD; sponsored by NBS; contact: Ronald F. Dziuba, A247 Metrology Building, 301/921-3806.

May 10-12
SEVENTH SYMPOSIUM ON THERMOPHYSICAL PROPERTIES, NBS, Gaithersburg, MD; sponsored by NBS and the American Society of Mechanical Engineers; contact: Ared Cezariliyan, Room 124, Hazard Building, 301/921-3687.

May 16-18
CONFERENCE ON CORROSION OF METAL IN BUILDINGS, NBS, Gaithersburg, MD; sponsored by NBS; contact: Dr. G. Frohnsdorff, B350 Building Research Building, 301/921-3458 or Dr. J. Kruger, B252 Materials Building, 301/921-2094.

***May 17-19**
MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: Harry Burnett, B260 Materials Building, 301/921-2813.

May 19
TRENDS AND APPLICATIONS SYMPOSIUM COMPUTER SECURITY AND INTEGRITY, NBS, Gaithersburg, MD; sponsored by NBS; and IEEE Computer Society; contact: Marshall Abrams, B212 Technology Building, 301/921-2601.

June 2
SYSTEMS AND SOFTWARE: OPERATIONAL RELIABILITY AND PERFORMANCE ASSURANCE; 16th Annual Technical Symposium, NBS, Gaithersburg, MD; sponsored by the Association for Computing Machinery, Washington, D.C. chapter, and NBS. Contact: Stuart Katzke, A265 Technology Building, 301/921-3861.

****June 13-15**
CONFERENCE ON ULTRASONIC TISSUE CHARACTERIZATION, NBS, Gaithersburg, MD; sponsored by NBS; contact: Melvin Linzer, A329 Materials Building, 301/921-2858.

August 9-11
FIFTH SYMPOSIUM ON THE SIMULATION OF COMPUTER SYSTEMS, NBS, Gaithersburg; sponsored by NBS and the Special Interest Group on Simulation of the Association for Computing Machinery; contact: Paul Roth, B250, Technology Building, 301/921-3545.

September 21-23
SYMPOSIUM ON ROOFING TECHNOLOGY, NBS, Gaithersburg, MD; sponsored by NBS and the National Roofing Contractors Association; contact: Robert G. Mathey, B348, Building Research, 301/921-3407.

***September 28-30**
DATA ELEMENT MANAGEMENT SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and ANSI Committee X3L8; contact: Hazel McEwen, B226 Technology Building, 301/921-3157.

***October 11-13**
MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS, Gaithersburg, MD; sponsored by NBS, Energy Research and Development Administration, Electric Power Research Institute; contact: S. J. Schneider, B303, Materials Building, 301/921-2893.

***November 1-3**
MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: Harry C. Burnett, B260 Materials Building, 301/921-2818.

***December 5-7**
WINTER SIMULATION CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS, the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers, Operations Research Association of America, the Institute for Industrial Engineers, and the Society for Computer Simulation; contact: Paul F. Roth, B250 Technology Building, 301/921-3545.

* New Listing
** This conference was originally scheduled for June 6-9.

NEW ENERGY MANAGEMENT GUIDE FOR SMALL BUSINESS

Energy Management Guide for Light Industry and Commerce, Kelnhofer, W. J., and Wood, L. A., Nat. Bur. Stand. (U.S.), Handb. 120, 28 pages (Dec. 1976), SD Catalog No. C13.11:120, 70 cents.

The *New Energy Management Guide for Light Industry and Commerce* describes some simple methods by which managers of small businesses can analyze their energy use, determine the areas in which energy savings can be made and estimate the magnitude of possible cost savings. The book was developed by the National Bureau of Standards and the Office of Energy Programs of the Domestic and International Business Administration.

The 23-page guide is intended for those businesses whose primary use of energy is for heating, lighting and refrigeration. Examples would include motels, food stores, laundries, garages, job shops and small assembly plants. The guide points out that small businesses are especially affected by high energy prices, because their profit margins are usually smaller than large businesses. Even a moderate saving in energy costs can make the difference between a healthy business and one that is forced to close, the guide notes.

The guide begins with a description of how to conduct an energy audit. This audit is designed to locate the major uses in a business and the most promising targets for energy conservation. The methods described require little or no instrumentation; they primarily involve summarizing data taken from such sources as light bulb labels and the nameplates on electric motors. The importance of this audit is stressed as a necessary prelude to a good energy management program.

The guide then provides a checklist of 70 Cost Saving Opportunities (CSO's) divided among four areas: buildings and grounds, electricity, equipment and processes, and vehicles. A few examples of CSO's from the booklet are:

- Reduce ventilation rates when possible
- Review energy Efficiency ratings for all new electrical equipment
- Insulate bare steam, hot water and chilled water lines
- Size vehicles to the job

Eight of these opportunities are presented as miniature case studies, illustrating simple methods for estimating savings. The case studies range from the simple case of reducing temperature at night and on weekends (saving up to a third of the heating fuel) to the more complex case of installing a heat exchanger on a restaurant air conditioner (costing $800) in order to save money in heating water (saving $1100 annually).

The guide points out that while many energy conservation actions require no outside help and little or no expenditures, others may involve larger expenditures or even capital investment and should be discussed with an expert in the field. Sources of assistance to help in such decisions are listed in the guide.

The new guide is part of the EPIC Energy Management Series of the Department of Commerce, publications designed to assist business leaders in developing and maintaining effective energy management programs. This series grew out of the original EPIC (Energy Conservation Program Guide for Industry and Commerce) handbook, published jointly by NBS and the Federal Energy Administration. EPIC, NBS Handbook 115 (SD Catalog No. C13.11:115), is available for $2.90 a copy, and NBS EPIC Supplement 1 (SD Catalog No. C13.11:115/1), is available for $2.25 a copy from the U.S. Government Printing Office.

MEASURES FOR RADIATION SAFETY

Measurements for the Safe Use of Radiation, Fivozinsky, S. P., Nat. Bur. Stand. (U.S.), Spec. Publ. 456, 450 pages (Nov. 1976), SD Catalog No. C13.10:456, $5.15.

Over 50 papers dealing with the measurement of radiation for medical use and environmental studies are contained in a new publication from the National Bureau of Standards, *Measurements for the Safe Use of Radiation.*

Originally delivered at an NBS 75th Anniversary Symposium held last March at the NBS facilities in Gaithersburg, Md., the papers discuss current and future requirements for the precise measurement of both ionizing and non-ionizing radiation.

Scientists and federal and state officials with responsibility for radiation measurement attended the symposium to discuss how the national measurement system for radiation could be improved to assure that measurements are correctly made, adequately accurate, and traceable to national standards.

Measurements for the Safe Use of Radiation includes papers on such subjects as the control of dosage in radiotherapy, radiation measurements for diagnostic radiology, and the measurement of environmental radiations. Measurement of non-ionizing radiations, such as optical radiation from UV lamps and lasers as well as radio frequency radiation from portable transmitters is also discussed.

OF THE NATIONAL BUREAU OF STANDARDS

Acoustics and Sound

Magrab, E. B., Ed., *Environmental Effects on Microphones and Type II Sound Level Meters*, Nat. Bur. Stand. (U.S.), Tech. Note 931, 120 pages (Oct. 1976) SD Catalog No. C13.46:931, $1.85.

Zapf, T. L., Harvey, M. E., Larsen, N. T., and Stoltenberg, R. E., *Ultrasonic Calorimeter for Beam Power Measurements*, Nat. Bur. Stand. (U.S.), Tech. Note 686, 36 pages (Sept. 1976) SD Catalog No. C13.46:686, 85 cents.

Building Technology

Debelius, J. R., Weber, S. G., and DeCorte, K. N., Eds., *Building Technology Publications 1965-1975*, Nat. Bur. Stand. (U.S.), Spec. Publ. 457, 107 pages (Dec. 1976) SD Catalog No. C13.10:457, $1.80.

Lew, H. S., Reichard, T. W., and Clifton, J. R., *Concrete Strength During Construction*, Nat. Bur. Stand. (U.S.), Tech. Note 923, 56 pages (Dec. 1976) SD Catalog No. C13.46:932, $1.35.

Yancey, C. W. C., *The Development of an Improved Test for Evaluating the Racking Resistance of Wall Panels*, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 91, 75 pages (Nov. 1976) SD Catalog No. C13.29/2:91, $1.40.

Health and Safety

Linzer, M., Ed., *Ultrasonic Tissue Characterization. Proceedings of a Seminar held at the National Bureau of Standards, Gaithersburg, Md., May 28-30, 1975*, Nat. Bur. Stand. (U.S.), Spec. Publ. 453, 274 pages (Oct. 1976) SD Catalog No. C13.10:453, $3.55.

Consumer Information and Protection

Westin, A. F., *Computers, Health Records, and Citizen Rights*, Nat. Bur. Stand. (U.S.), Monogr. 157, 401 pages (Dec. 1976) SD Catalog No. C13.44:157, $4.55.

Electronic Technology

Goodman, A. M., *Semiconductor Measurement Technology: Safe Operation of Capacitance Meters Using High Applied-Bias Voltage*, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-34, 57 pages (Dec. 1976) SD Catalog No. C13.10:400-34, $1.45.

Energy Conservation and Production

Kelnhofer, W. J., and Wood, L. A., *Energy Management Guide for Light Industry and Commerce*, Nat. Bur. Stand. (U.S.), Handb. 120, 28 pages (Dec. 1976), SD Catalog No. C13.11:120, 70 cents.

Rubin, A. I., *Energy Conservation in Buildings —A Human Factors/Systems Viewpoint*, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 88, 19 pages (Nov. 1976) SD Catalog No. C13.29/2:88, 65 cents.

Engineering, Product and Information Standards

Vickers, M. V., *COBOL Coding Form*, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 44, 3 pages (1976) SD Catalog No. C13.52:44, $3.50.

White, H. S., Ed., *Guide for the Development, Implementation and Maintenance of Standards for the Representation of Computer Processed Data Elements*, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB), 51 pages (1976). Order from NTIS, Springfield, Va. 22161.

Environmental Studies: Pollution Measurement

Maienthal, E. J., Becker, D. A., *A Survey of Current Literature on Sampling, Sample Handling, and Long Term Storage for Environmental Materials*, Nat. Bur. Stand. (U.S.), Tech. Note 929, 40 pages (Oct. 1976) SD Catalog No. C13.46: 929, 85 cents.

Measurement Science and Technology Physical Standards and Fundamental Constants

Judson, L. V., *Weights and Measures Standards of the United States—A Brief History*, Nat. Bur. Stand. (U.S.), Spec. Publ. 447, 44 pages (Mar. 1976) SD Catalog No. C13.10:447, $1.00.

Mechanics: Design, Testing and Measurement

Hilten, J. S., Lederer, P. S., Vezzetti, C. F., and Mayo-Wells, J. F., *Development of Dynamic Calibration Methods for Pogo Pressure Transducers*, Nat. Bur. Stand. (U.S.), Tech. Note 927, 58 pages (Nov. 1976) SD Catalog No. C13.46:927, $1.15.

Thermodynamics and Chemical Kinetics

Staples, B. R., and Nuttall, R. L., *Computer Programs for the Evaluation of Activity and Osmotic Coefficients*, Nat. Bur. Stand. (U.S.), Tech. Note 928, 56 pages (Dec. 1976) SD Catalog No. C13.46:928, $1.10.

Publications listed here may be purchased at the listed price from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, Va. 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

NEWS BRIEFS

SYSTEMS TO PROTECT NUCLEAR MATERIALS NBS has completed contract arrangements with the Defense Nuclear Agency on systems to improve the protection of nuclear materials and to safeguard valuable property and information. Performance requirements and design parameters will be developed for Computerized Site Security Monitor and Response Systems.

STUDY CALLS FOR ACTION TO PROTECT PRIVACY OF HEALTH RECORDS Guaranteeing citizens the right to control how information in their personal health records is to be used is one of 12 recommendations described in the first comprehensive study of privacy issues in a specific area of American society. The recommendations are contained in a report on Computers, Health Records, and Citizen Rights released on January 12. The two-year study was funded by NBS and conducted by Alan F. Westin.

NBS TO AID UNITED NATIONS' HEALTH ORGANIZATION NBS has been designated by the World Health Organization as a Collaborating Center in Clinical Chemistry. As such, NBS will advise and assist WHO to develop standard technical methods and control materials in clinical chemistry. The goal of the WHO program is to improve the diagnostic services of the clinical and public health laboratories throughout the world. WHO sponsors four other organizations worldwide as clinical chemistry centers, including the Center for Disease Control in Atlanta.

ECONOMIC STUDY OF CORROSION UNDERWAY The NBS Institute for Materials Research and Battelle-Columbus have jointly undertaken a broad survey of the economic effects of corrosion in the United States. The goal of the study is to determine the total cost of corrosion of metals. The study will also determine: which sectors of the economy suffer significant corrosion losses; and the capital goods, energy, materials, and other resources required because of corrosion. The study is sponsored by NBS.

NEW RESEARCH ASSOCIATE PROGRAM BEGUN The Aluminum Association, Inc., and the American Electroplaters' Society are sponsoring a scientist to work at the NBS laboratories in Gaithersburg, MD., in the Research Associate Program on the problems of adhesion of chrome plating on aluminum. One of the uses of chrome-plated aluminum is for automobile bumpers to reduce weight and save gasoline.

GET A PERSPECTIVE ON STANDARDS. The NBS annual report covering July 1975 through September 1976 is now available. It outlines Bureau contributions to increased measurement capabilities, better materials use, environmental protection, conservation of energy resources, building technology, public safety, computer applications, and information resources. Order from the Government Printing Office, Washington, D.C. 20402, Stock Number 003-003-01716-7, for $1.20.

NEXT MONTH IN

DIMENSIONS NBS

What secrets of ecology lie hidden on the ocean floor? Researchers are beginning to probe the depths to answer that question Their search is being aided by a new device that brings microscopic, pressure-loving organisms from the deep sea to the laboratory—alive—for scientific study. The April issue of DIMENSIONS will report on this development and its importance in environmental research.

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Robert T. Cook, Acting Chief

Richard S. Franzen, Chief, Editorial Section

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The National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their effective application for public benefit. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method development, and standards writing. DIMENSIONS/NBS describes in technical and general terms results of NBS activity in areas of national concern such as energy conservation, fire safety, computer applications, environmental protection, materials utilization, and consumer product safety and performance. The functions of NBS are divided into four major Institutes: Institute for Basic Standards, Institute for Materials Research, Institute for Applied Technology, and Institute for Computer Sciences and Technology.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $9.45, foreign, $11.85, single copy, 80 cents. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1981.

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